

PHYSICS AND CHEMISTRY
for
PRE-SECONDARY STUDENTS
in
NEW ZEALAND

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ABSTRACT

In 1996 we set out to show that primary teachers could teach the new physical science curriculum with no further training if they had the right books. We searched the literature for didactics which had been shown to positively impact learning so that we could incorporate those features into any books we would make.

We conducted a pilot project for which we wrote and printed 30 workbooks for one activity. Next, we sent out a book survey to find what books were available for the subject in New Zealand at that time. Simultaneously, we scoured Europe, Asia and North America for good lesson material. We found material which incorporated the didactic criteria from our literature search and adapted some of it for our study, producing about 12,000 guided workbooks for each of the last four pre-secondary years, 3000 for each age nine to twelve. The books were made available to all New Zealand schools.

Two groups of about 12 teachers each formally trialled the books. One group answered questionnaires and the other kept action research journals. Both groups confirmed the principal research premise—teaching hours increased with no further training.

Once good books were in hand other problems became apparent. A nationwide resources survey revealed a lack of equipment and other problems such as poor classroom design, awkward grouping of children of different ages and abilities, lack of time, dysfunctional open plan classes of 100 pupils, two-year teaching cycles, competition from free resource packs, and lack of support material such as videos.

From this study it can be concluded that the books made a positive impact for teaching physical science. The books gave teachers an international standard of lessons to work from. It was shown by this study that a teacher with no background in physics or chemistry can teach primary physical science at an international standard once good books are in hand as long as poor equipment, space and facilities are not too serious a set of impediments.

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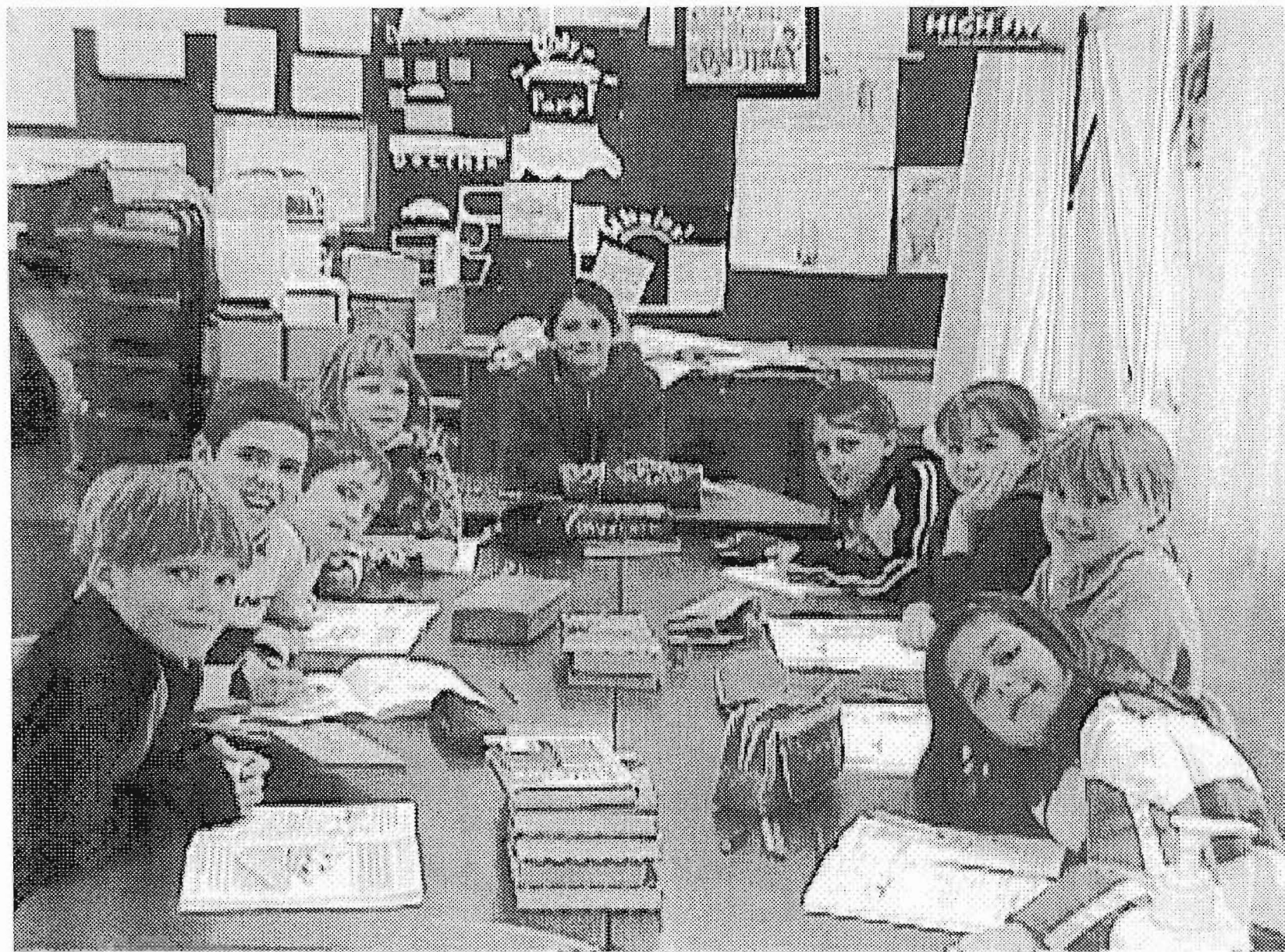
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GLOSSARY

ACER	Australian Council for Educational Research
DOE	Department of Education
ERIC	Education Resources Information Center
ERO	Education Review Office
FIMS	First International Math Study
FISS	First International Science Study
KISS	Kiwi Integrated Science Series
IEA	Int’nl Assoc’n for Evaluation of Educational Achievement
IMSS	International Math and Science Study
IT	Information Technology
L	Level
MOE	Ministry of Education
NSL	National Library Service
NZ	New Zealand
NZCER	New Zealand Council for Educational Research
NZER	New Zealand Education Review
PAT	Progressive Achievement Test
PSPS	Pre-Secondary Physical Science Project
SIMS	Studies in Math and Science
SIMSS	Second International Math and Science Study
SISS	Second International Science Study
SPSS	A statistical package known as SPSS (http://www.spss.com)
TIMS	Third International Math Study
TIMSS	Third International Math and Science Study (originally)
TIMSS	Trends in Mathematics and Science Study (now)
Yr, Y	School Year



Students in Hamilton reading Book 1 produced in this project.

CHAPTER 1 OVERVIEW

1.1 Introduction

In this section the research problem is introduced, a précis of each chapter in the thesis is given, and some outcomes of the work are presented.

The New Zealand (NZ) curriculum documents are guidelines for what is taught in NZ schools. They are updated periodically. In 1993 a revision occurred based on continuous strands of learning (Ministry of Education (MOE), 1993). If physical science (physics and chemistry) was taught in the final school years 12 and 13, a continuous strand of learning meant it would be taught in the early years as well.

In 1996 an Education Review Office (ERO) report found that physical science was under-taught in pre-secondary grades. The report faulted primary teachers for not knowing the new curriculum and avoiding teaching it (www.minedu.govt.nz; NZER, 1996; see also Ch. 2.3, Fig. 2.3 p36).

In 1997 NZ primary students placed below average (16th out of 25 countries) on the Third International Math and Science Study (TIMSS) in this subject area. It appeared that under-teaching could be having a negative effect on student learning.

This project began in 1996 with the premise that good classroom books would serve to increase teaching hours in the subject. Problematic texts for primary science have recently been noted in New Zealand science education literature (Austin, L., 2002). A research project investigating pedagogical features of books combined with the production and trial of those books was long overdue.

There was a public debate in the mid 1990's about how primary physical science could be taught by primary teachers who had no science background. Many argued that teachers would need further training. The conceptual basis of this study was that any material meant to be understood by 9-year old children could be

understood by their teachers including those not trained in science. It would be shown in this project that the new curriculum could be delivered with no further teacher training if good books were in hand. One objective of the project was to find the features of books having a positive impact on learning and to produce books with those features.

Chapter 1 gives an overview of the research problem and a précis of each chapter in the thesis. It includes background references on developmental neurobiology and also defines the research questions as initially and finally posed.

Chapter 2 of this thesis is a literature review. It describes the TIMSS and other tests and the middling test scores. It gives social and historical reasons for the problem, and explores solutions to the problem involving resources. It reviews didactics including features of linear text such as inclusion of new vocabulary, use of numbers, sketching, writing, speaking, personal and pleasant presentation, etc. which positively affect learning outcomes. Many of these features were at odds with educational theories in NZ in the mid 1990's. The goal was to create material which could enhance learning and retention, create a feeling of ownership of learning, induce a favorable attitude toward the subject and be easy to use. Chapter 2 is summarized in Section 2.10.

Chapter 3 gives a brief overview of research methods and approaches considered for and used in this project. It has a concrete example to inform those involved with this project who had no prior experience in social research. It explains why "dosing" and pre- and post -testing 24 classrooms was not an appropriate design for this project. The ERO (Fig. 2.3) report of 1996 stated that the official curriculum did not match the curriculum being delivered in the classroom. Reality lay somewhere in between so an open-ended, naturalistic design was deemed best.

Chapter 4 describes the pilot project with one guided workbook and one activity. This was trialled 1.5 hours a week for four weeks with a class of 12-year olds. It was found that the regular teacher did not want to teach science. The room was not suitable for lab activities. All the equipment for all the children for measuring

liquids and solids, weighing, transferring, etc. had to be brought in before each lesson. The desks had to be shoved aside and students had to crawl around the floor because there was no suitable bench. The student in the wheelchair was disadvantaged. It was nearly impossible to implement the new curriculum. The students liked the workbooks, coloured them in and wrote on them. But, except for our project, they would not do any active physical science until high school. The situation was typical of that reported by the ERO in 1996 (NZER, 1996; Fig. 2.3).

Chapter 5 describes the book survey conducted to find what books were available for the new curriculum and to get comments from teachers and principals. The survey showed material was lacking then and was strongly requested.

There is nothing in the thesis describing the years of work involved in producing the books, collecting the equipment, testing all the activities for all four years, distributing the books nationwide, or hand-making hundreds of teacher guides and supply lists. In this aspect the project was excessive in the work required. In the process of gathering ideas it was found that the top scoring country on TIMSS, Singapore, had for decades used material with features that our literature search had revealed was optimal (Chng, 1981). It was also de facto well trialled and of top international quality. That material has now (2004) been out of print for several years, but at the time parts of it were adapted purposely for this study. Local artists were employed and it is their work which is protected for them by the copyright statement in the books and on this thesis. The copyright statement also protects the children's work and images although much of it has been deleted from the thesis to protect it. Time and money was also invested in developing teaching tools such as periscopes and puzzles, but for the same reasons, information about these has been omitted from the thesis.

Chapter 6 describes the resources survey sent nationwide. The survey contained additional questions about attitudes. During the years after the new curriculum was introduced other text resources became available. But it was evident there were still underlying problems. About 70% of the schools returning the survey had no equipment or space or facilities for teaching this subject. In the same survey a

statistic at odds with the low test scores was that virtually all the respondents reported that children were enthusiastic about this curriculum area. Furthermore, the teachers enjoyed teaching it because of the enthusiasm of their pupils.

Chapter 7 reports the work with teachers and their pupils who used the books and answered questionnaires. Both groups were pleased with the books overall. The students reported completing only parts of the books and having to share equipment. There was a significant difference between girls' and boys' attitudes to group work. Girls were more negative toward it.

Chapter 8 reports the journal entries of the twelve teachers who participated in action research as well as the comments of their pupils. The results once again showed the material was well received, but that other problems persisted.

In both the questionnaire and journal studies teachers were free to use the books how, when, and with whatever class they wished. The books were thus incorporated normally over a one or two-year period without researcher intervention.

Chapter 9 gives a bit of information about the education system of the area from which the content was adapted, Singapore. The differences between the countries is great and this was not a comparative study, but since there was some anecdotal evidence that NZ students did not cover the content as thoroughly as the Singaporean counterparts the information is included here.

Chapter 10 gives a brief summary and some implications and contributions of the study. The books themselves were one contribution. Several hundreds of teachers at Intermediate, Primary, Secondary, Te Kura Kaupapa, Special Needs, Home Schools, Juvenile Homes, etc. ordered the books. They have been translated into Maori. They have been purchased by other resource providers in Australia and New Zealand and taken apart and sold as separate lesson plans. They are used as desk reference sets from which lessons can be photocopied or as class sets so pupils can each have a book. Many people have thus benefited from the fruits of

this study although they were not a part of it. The books empowered teachers and pupils, but there is still room for improvement in the delivery of the primary physical science curriculum.

The aim of this project was to improve physical science teaching in the late-1990's after the new curriculum came out but before other supporting material was available. At that time many people thought pupils would not like these subjects as they were considered dry and difficult.

This study was qualitative. It was limited to a small number of schools. The objective was not to prove a hypothesis as much as to explore the issues. Some of the findings were unexpected and surprising. Some schools had insurmountable problems, but since 1996 many intermediates and primaries have built excellent facilities, focused money and personnel on improving this area of education and now teach at a top level. Since the book survey of 1997, so many new titles have appeared that teachers are spoilt for choice and there are far too many to list.

Most of the years of work and all the funds were devoted to producing materials for classrooms. The grant paid artists, their art supplies and the printer. It would have been inappropriate to have spent additional funds on larger surveys, questionnaires, data analysis and so forth as the total cost and time of the project already far exceeds others in this subject.

The project is expected to continue in the year following the submission of the thesis as the reports and other materials are returned to the teachers and their final thoughts and comments collated.

Some of the achievements, findings or outcomes from the study are listed below. This information pertains to the period from 1996 to 2002 when the work was done. The teaching in this subject has been constantly improving as would be expected for any new curriculum area. Although the books were available for all schools, for several reasons including costs to the author, only a very small number of teachers were directly involved in the studies.

These points are based on the qualitative data from a very small sample of teachers.

- The project was supported by a \$60,000 grant for education.
- 12,000 student workbooks of international standard and quality, 3000 for each of the last four pre-secondary school years were published and distributed.
- Equipment for all the activities was made or gathered and all activities were tested. Suppliers in NZ for the equipment were listed for every activity.
- Pupil enthusiasm about learning physical science was high.
- Pupil enthusiasm about having workbooks was high.
- Teacher interest is driven at least in part by pupil enthusiasm and not necessarily by the teacher's subject knowledge or lack thereof.
- There is under-teaching of physical science in the four pre-secondary years.
- Many classrooms lack proper equipment and supplies, space, and facilities.
- Primary physical science may have been added to the curriculum without adequate appreciation of the costs and practical logistics of teaching it. No mention of these issues was made in the ERO report of the 1996.
- The student workbooks and teacher guides enabled the teaching of physical science with no further teacher training or other support.
- Once set up with adequate gear the anticipated 'hard yards' were not hard.
- Other subjects taught instead of physical science are equally well-justified, important, useful and enjoyable for the pupil.
- The private academic school in the study set a high standard for physical science education and had a specialist science teacher.

It would be useful to do follow up studies on several of these points using larger samples. Some of these points can be used as indicators for further investigations.

1.2 Do Touch!

There are a few basic concepts which could be called 'assumed background knowledge' for this project in that there is a biological basis for learning. The last few decades have witnessed an explosive growth in genetics, the neurosciences and the understanding of brain function. However, much of what is known still depends on behaviour observation. The following three concepts are particularly important.

Concept 1

It has been shown that there are windows of time when certain genetic capacities can be triggered by the environment. For one example, Lorentz found that imprinting behaviour in ducklings would only occur between 15 and 72 hours after birth (Nisbett, 1976). For another, it is known from the rare cases of children who have been isolated from interaction requiring speech in the first few years of life that the ability to speak cannot be gained once that critical period has passed. It cannot be revisited and acquired later (Ridley, 2003b). There is evidence that similar windows for maximal future attainment in quantitative and abstract thought open for a period of time during the primary years. These are abilities associated with achievement in physical science and mathematics. Thus, there is a certain urgency to 'get it right', to provide 'nucleation sites' for brain cell growth, to provide stimuli and opportunities during those neural growth spurts prior to the 'hardwiring' of the pathways (Edelman, 1992). There is no second chance for some types of learning.

Concept 2

When the first cell of the cytoplasmic disc in the embryo first splits and involutes, three primary cell layers with three distinct ultimate fates are formed. These three fundamentally different types of cell are known as the ectoderm, endoderm and mesoderm. The ectoderm cells give rise to the outermost layer of the body—the skin, the eye lens, the surface of the mouth, the nasal cavity and anal canal. The endoderm

gives rise to the innermost layers of the body—respiratory passages, lungs, liver, pancreas, thyroid and bladder. The mesoderm gives rise to the tissues in between—muscle, blood, connective tissue and bone. But, ...

“One major tissue located topographically between the skin and the gut does not develop from the mesoderm. This is the nervous tissue, which, curiously enough is derived from the ectoderm. Soon after gastrulation, the ectoderm becomes divided into two components, the epidermis and the neural tube. A sheet of ectodermal cells lying along the midline...bends inward and forms a long groove extending most of the length of the embryo...This neural tube becomes detached from the epidermis above it and in time differentiates into the spinal cord and brain.” (Keaton, 1967)

Nervous tissue, *the skin and the brain* are all ectodermal cells and are thus fundamentally the same tissue. It has been argued that hands-on activities which provide tactile sensory input, activities in 3-dimensions and real space with real gravitational forces (not vectors on a computer screen) are of special importance in the neurobiological development of the brain and brain stem (Edelman, 1989). Children grab things naturally and need to be provided the opportunity to explore with their hands, to ‘think’ with their hands, to move in real space with various objects and to learn and understand in a tactile way.

Concept 3

Neuronal selection in the brain is against simplicity more than it is against complexity and the degree of complexity is endless (Edelman, 1987). The more perceptual experience the brain undergoes, the more fully it will develop. This is nothing new, of course, but is only re-stated to emphasize the importance of giving pupils adequate opportunities for hands-on experiences from ages 9-12 which can contribute not only to learning, exploring and discovering, but to enhancing and increasing the complexity of neurological development as well (Edelman, 1992). It is society’s loss if these years are wasted.

1.3 Research Questions

The research question as initially posed using the perturbation model was...

What did the introduction of books to the system tell us about the system as it existed before and as it exists after the introduction?

The *system* is defined as the state of physical science teaching including a myriad of variables, known and unknown about teachers, students and facilities, and the books would be those made in this project. To ‘find out’ in this way was the approach originally taken. More specific research questions would have required more robust statistical methods than were available at that time and more evaluative judgments and self-limiting assumptions about the system than were appropriate.

The research question as finally posed is more specific.

The first question has *teaching time* for physics and chemistry as the dependent variable and *books* as the independent variable:

Is teaching time in physical science dependent on books?

Stated as a hypothesis with a directional correlation:

Teaching time in physical science is dependent on books and
teachers spend more time teaching if they have more books.

Several intervening or confounding independent variables have been identified and some are listed as related questions below:

- a. Is teaching time dependent on equipment?
- b. Is teaching time dependent on classroom design?
- c. Is teaching time dependent on age-grouping of children?
- d. Is teaching time dependent on teacher science background?

- e. Is teaching time dependent on teacher gender?
- f. Is teaching time dependent on school decile?

A second research question concerns books. The dependent variable is the quality 'useful'. The term 'good' has also been used in the same context. The independent variable may be expressed as *expository*:

Does the usefulness of a book depend on the extent to which it is expository?

Intervening independent variables can be listed as related research questions:

- a. Is the usefulness of a book dependent on being write-on?
- b. Is the usefulness of a book dependent on encouraging discussion?
- c. Is the usefulness of a book dependent on providing new vocabulary?
On incorporation of numeracy? On providing guided learning? On opportunities to sketch concepts? On the use of numbers in graphing? On an activity basis for each concept? On group or independent work? On size 14 Arial font up to age 10? On local references? On being well tested and trialled? On friendly cartoons?

Stated as a hypothesis, for example:

A book is useful if it is expository and offers opportunities for learning new vocabulary and a book is more useful if it is more expository and has more opportunities for learning new vocabulary.

Other linkages and factors confounding the teaching of physical science included:

- knock on effects of historical testing practices at both primary and secondary levels
- overcrowded curriculum
- open plan classrooms
- lack of equipment for activities
- competition from other teaching packages

to name a few.

Operational definitions

- teaching time: time per term or year spent on teaching the physical science syllabus—any part of it at any level
- books: text resources, usually in the form of lesson plans including the books made in this project
- usefulness: a subjective value placed on a book by a teacher or student reflecting their perception of its pedagogic utility
- expository: information presented fully, in a variety of ways-words, pictures, etc.
- constructivist: questions posed to reader, information required of reader (as related to debates about constructivism that raged in New Zealand and elsewhere in the mid-1980's-1990's)

Feedback from teachers and students was used to inform the research. The methods included a combination of questionnaires, surveys and journals. For ethical reasons, no testing of students was done at any stage of this work.

The specific aim of this project was to improve teaching of pre-secondary physical science. In the mid-1990's it was under-taught and when the new curriculum first came out supporting material was scarce. Materials made as part of this project were meant to help bridge the gap between the new curriculum statements and their implementation.

This project was based on a naturalistic design and was not set up to evaluate a causal hypothesis as might have been done with an experimental design. The advantage of this applied research approach is that both sides can get immediate benefits -information is provided for research and resources are provided to classes.

CHAPTER 2 PERSPECTIVES ON THE PROBLEM

The following is a brief description of the parts of this chapter.

Part 2.1 gives definitions of important terms, possible reasons why physical science was not emphasized prior to 1993 and shows pages of typical books which would suggest why the topic was ill understood and educators were apprehensive about it being taught by untrained primary teachers.

Part 2.2 gives a review of test scores which show mediocrity in physical science and point to a problem. Some information is given about the tests and other factors affecting test scores.

Part 2.3 gives the ERO report of the problem in 1996 and a review article of the situation as it existed in 1996 and the problem that was the basis for this project.

Part 2.4 gives a brief description of teacher training. Historically little science was required for primary teaching. From the post war era many countries developed intermediate schools with specialist teachers in each subject, but for the most part, for various economic reasons, New Zealand kept the primary structure to age 12 and secondary from age 13 with few intermediates. Thus, primary trained teachers were teaching intermediate age students and may not have had sufficient training.

Part 2.5 describes some contributions from New Zealand in the teaching of primary science. Some have argued that some of these methods were developed to compensate for teachers lack of specific science knowledge. Some of the ideas may therefore now be considered contrary to best practice, but were useful at the time.

Part 2.6 goes on from 2.5 and describes some terms used in the 1990's and earlier for approaches to thinking about teaching and learning.

Part 2.7 justifies the need for books as opposed to videos, computer programs, etc.

Part 2.8 and 2.9 describe content and skills which can be incorporated into books.

Part 2.10 is a summary of the chapter.

2.1 Over the Years

“The most important single factor influencing learning is what the learner already knows.” (Ausubel, 1978)

What should the student “already know” entering secondary school?

Prior to the publication of the revised curriculum of 1993, primary school science was treated as a general subject. Physical science units (pulleys, separation of mixtures, etc.) could be taught if the teacher wished, but more often these topics were left to Years 9 and 10 (Min of Ed., 1993). Physical science is often defined internationally as chemistry and physics with subtopics astrophysics and atmospheric chemistry (ERIC, 1989). These are under the headings Material World (chemistry), Physical World (physics) and Planet Earth and Beyond (astrophysics and atmospheric chemistry) in the curriculum (Min. of Ed., 1993).

The definition of the formal prescription for primary studies which lead directly to the secondary level of the same formal subject matter is internationally defined as ‘elementary secondary education’. To eliminate possible confusion this phrase is herein referred to as ‘pre-secondary’ education. This term covers the formal curriculum of the first 8 years of education. It includes full primaries (Y1-8) contributing primaries (Y1-6) and intermediates (Y7,8).

New Zealand has had national guidelines for science in the primary grades for over one hundred years (Ewing, 1970). It has always been the practice to allow the teacher to establish the daily classroom agenda (Dept. Ed., 1989). That work has been allowed to follow the interests of the teacher, the needs of the class, local geographical idiosyncrasies, availability of resources and any other pertinent conditions (Tannenbaum, 1960). With few exceptions the primary teacher is a generalist with possibly some background in life science and geography (Seager, 1987).

Over the last century the science curriculum has undergone continual change (Osborne, 1985). Some recent changes include a policy of science for all and attention to the needs of girls and minorities (Middleton & Jones, 1992; Min. of Ed., 1993). In many ways the need for change has paralleled developments in society and in the knowledge base itself. The needs of a society increasingly reliant on advances in chemistry and physics have forced a re-examination of the place of physical science in the junior curriculum (Am. Chem. Soc., 1994). What should be taught? How? What should a student know at the end of primary school? How do teaching strategies affect learning outcomes?

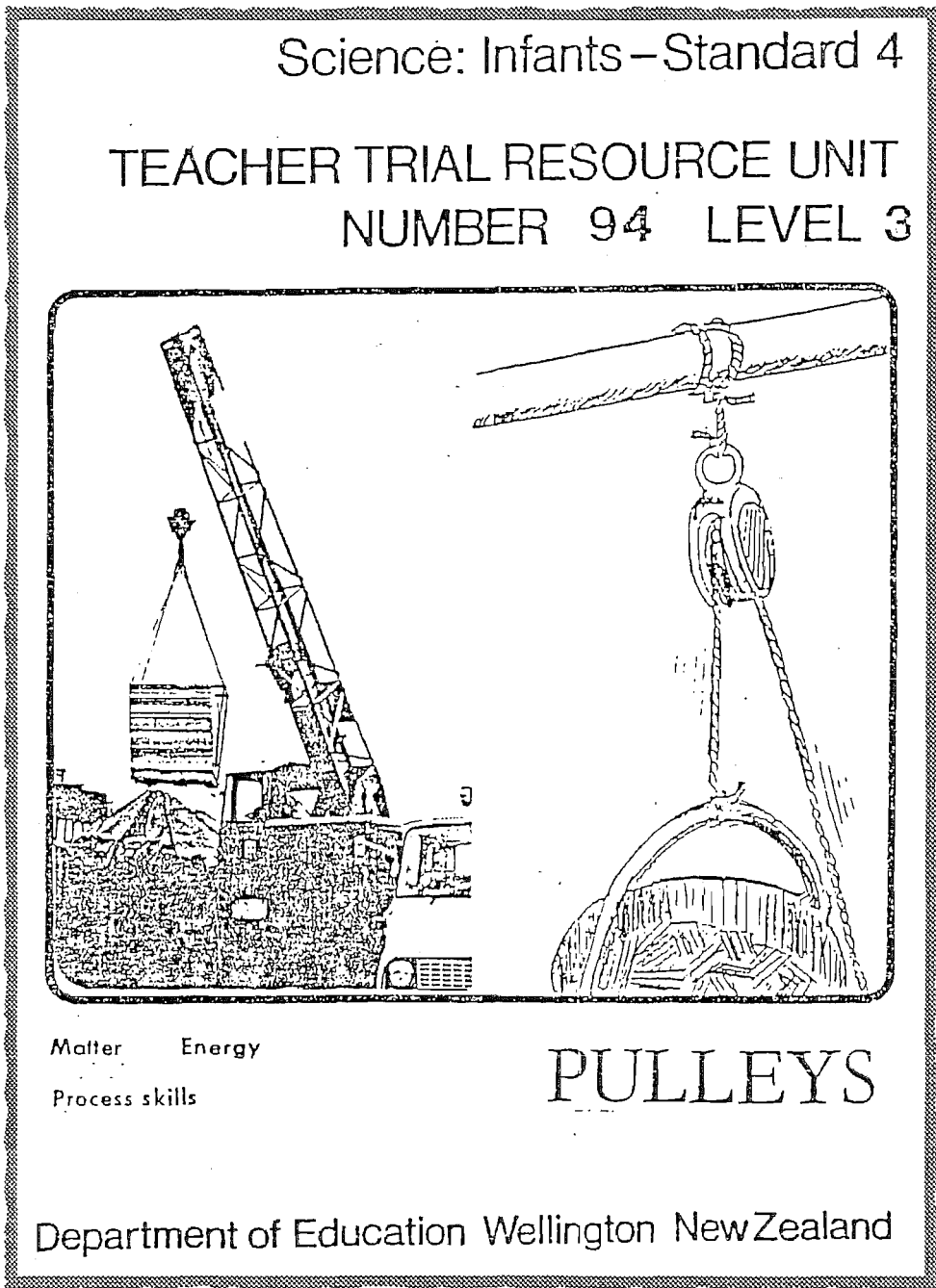
Over the years and for several reasons physical science has often been ignored. One reason was a teacher training bias that emphasized life science. This was compounded by a natural early curiosity in children about biological sciences (Baker, 1945). When asked, 'What do you want to learn in science?' lower primary children were found to respond with biological questions only (although upper primary students ask a broader range of questions).

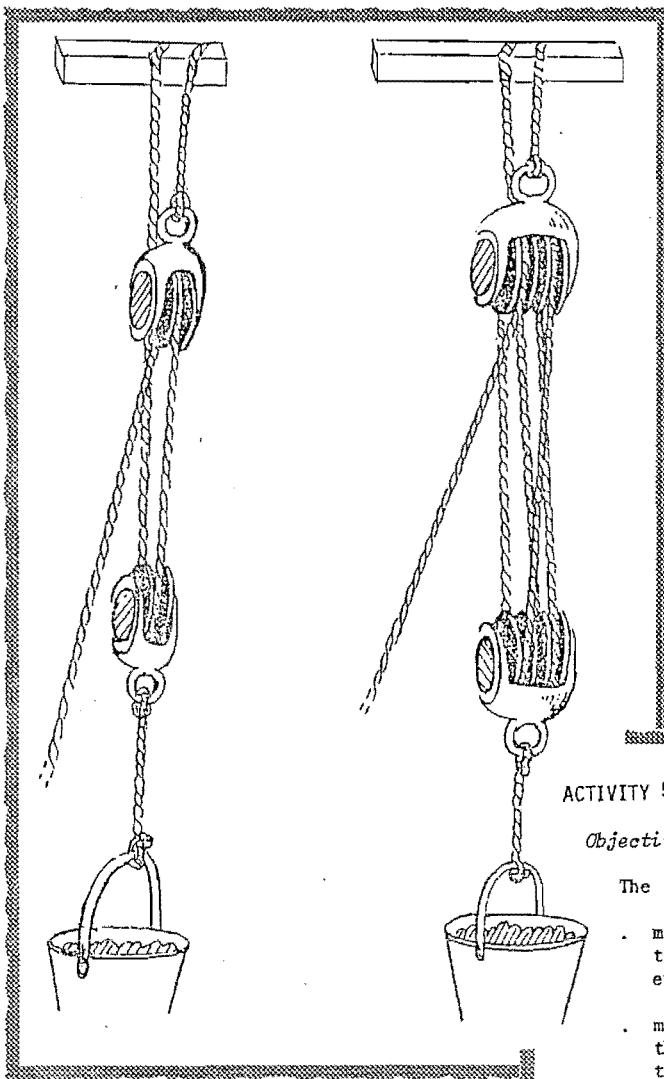
Ages 9—12 are important in educating the general public to a level of confidence about science. They are critical years when buds of lifelong interests can be established. Furthermore, parents, grandparents and other siblings are often involved and become secondary participants in the learning process. Foundations can be laid for subject choices in secondary school and beyond. The resources in the classroom contribute to the process as much as any other factors.

In the years immediately after the new curriculum guidelines were published in 1993 there was insufficient user-friendly teaching material in primary chemistry and physics. What was available then? Figure 2.1 shows an exact copy (x 0.71) of pages from a typical Department of Education publication of the time, *Resource Unit 94: Science for Infants to Standard 4* (Year 1 to 5/6). It is not surprising some teachers found it intimidating.

There was a need for the development of new teaching material in physical science.

Fig 2.1 An Example of a 1990's Primary Science Book





Quotations from the unit include:

“PROCESS SKILLS”

“Given the weight of the load, the height of the lift and a diagram of the pulley system or the actual pulley system the children can:

- *Predict the force in kg needed to lift the load.*
- *Predict the distance in cm the rope from the final pulley will move to lift the load a given distance.”*

ACTIVITY 5

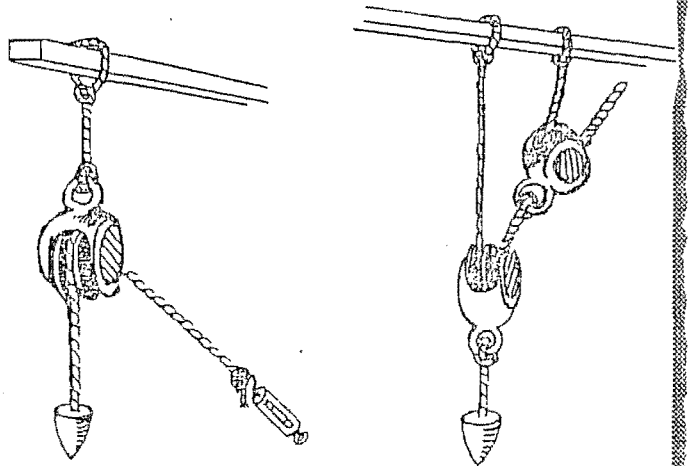
Objectives

The children can

- measure the force (weight, friction) in kg needed to lift a 2 kg object 50 cms using pulley systems employing 1, 2 or 4 pulley wheels.
- measure the distance from the final pulley that the rope moves, for each pulley system, to lift the load 50 cms.
- gather and tabulate data and translate to a graph.

Activities

- Use a set of scales or balance to measure the weight of the object. Measure with a spring balance, the force required to lift the object 50 cm using 1 pulley, 2 pulleys, and 4 pulleys.
- Tabulate results.



“A point to which pulleys can be securely fixed is essential to enable these activities to be safely carried out. A suitable securing point is a rope firmly attached to a structural beam.”

These instructions, diagrams, objectives and information would not be considered ‘user-friendly’ to a primary teacher with no science background and a class of 32 children 8-10 years old!

2.2 Mediocrity in Achievement Tests

Historically, New Zealand had not fared well in international tests of physical science at the late primary level. In 1970 nineteen countries took the International Association for the Evaluation of Achievement (IEA) tests in several subject areas. For the age 14 population tested in science Japan was the highest scoring country.

At that time New Zealand had the lowest school retention rate of the participating countries with only about 10% retained to the senior secondary level. Since this 10% had been retained after severe culling, it could be expected to mostly represent the top 10% of the total student population if it had all been retained to age 17. Much of the data reported by the IEA was uncorrected for comparative percentages of students retained. For the uncorrected 10% New Zealand achieved roughly the same level as Australia. These data are important as they affect and are an indicator of performance and expectations for the primary levels.

In 1981 New Zealand participated in the IEA math survey. Japan was the top scoring country. At Form 3 level New Zealand ranked slightly below the average of the means of the twenty countries tested (Robitaille, 1989). Australia and Japan participated in the 1989 Second International Science Study (SISS) but New Zealand did not. Japan was the top scoring country in the 1989 SISS. Australia scored at the average of the means of the participating countries (Rosier, 1990). England scored below the average of the means. Japan had the highest mean and lowest standard deviation. A sample of these data is shown in Table 2.1 below.

Table 2.1 SISS Data, 1990 (Rosier, 1990)

Country	Mean Score	Std. Dev.	Age (yrs:mos)	School Yr	Sample Size
Australia	53.5 %	18.8	10 : 6	5	4,259
Japan	64.3 %	16.5	10 : 7	5	7,924
England	48.8 %	18.6	10 : 3	5	3,748

At this age (10) and school year, retention in all countries was comparable. A test of the significance of the difference of these means showed that the probability of the results occurring by chance was near nil - the difference in means is quite significant (Brookes, 1960).

Because of the stability of these results over time with similar reference check tests, the consistency of Australia and New Zealand data, and the parity of the school systems and testing procedures, the Australia data is comparable and relevant to New Zealand and can be used as a predictor of trends in New Zealand (Northfield, 1991) and as an indicator of achievement in New Zealand (Comber & Keeves, 1973).

Since 1970 different countries have taken different subject tests at different times with different target populations. Linking data can be used to establish a current analytical framework for comparison between countries, interrelated subject areas, sequential form levels (populations) and different time frames. For example, since computational skills and mathematics are fundamental skills in physical science, weak SIMS (Second International Math Study) data indicate an underlying cause for weak SISS (Second International Science Study) data.

For another example, the 1979 PAT (Progressive Achievement Test) -N.Z (Math) data from Form 2 can be expected to parallel that for Form 3 although Form 3 was not tested that year. Based on these considerations it is possible to infer that, given a range of undeveloped and developed countries such as participated in the 1989 SISS, Japan was the top scorer in math and science and New Zealand was a mid-range scorer in math and science at comparable age levels.

PATs in difference subject areas are administered at regular intervals by the NZCER (New Zealand Council for Educational Research) and ACER (Australian Council for Educational Research) as well as most other IEA participant countries. These tests are administered for the purpose of norms-checking and to show the stability of the test results over time. The PAT tests are designed to be similar to the IEA tests. Both contain "bridging" questions from prior years and other internal checking devices. The IEA data are thus shown to have validity, reliability, continuity and stability.

The IEA tests themselves are the same for any given test date regardless of location. The data analysis and norms-checking are standardized. One possible bias in IEA data is the definition of ‘sample population’ and sampling technique. For example, the age 18 student population in a country which requires children to remain in school until age 18 will vary from the age 18 student population in a country which retains only about 10% of students by that age.

International tests are expensive and time-consuming. New Zealand did not participate in an International Association for the Evaluation of Achievement (IEA) Study in science from 1970 to 1994. In order to evaluate the national standard in an international context it is useful to (a) rely on linking data and internal tests which are stable over time, and (b) rely on Australian data which is stable with respect to New Zealand and an indicator of New Zealand standards.

The following timeline shows the general sequence of tests over recent years.

Table 2.2 Timeline of Studies and Tests:
IEA Studies in Math & Science (SIMS), NZCER Studies

A. INTERNATIONAL STUDIES			
	<u>Time</u>	<u>Study</u>	<u>Reference</u>
I.	1970	IEA	
		a. FISS: First Int’l Science Study (14 yr olds) #1 Japan	Comber & Keeves, 1973
		b. Reading Comprehension (14 yr olds) #1 New Zealand	Thorndike, 1973
II.	1981	IEA	
		a. FIMS: First Int’l Math Study (Form 3) #1 Japan	Dept Ed., 1987 Robataille & Garden, 1989
III.	1990	IEA	
		a. SISS: Second Int’l Science Study (10 yr olds) #1 Japan	Rosier & Banks, 1990
IV.	1994	IEA	
		a. TIMS Third Int’l Math & Science Study	Garden, 1996

B. NATIONAL STUDIES

- I. 1986 – 1981 NZCER Progressive Tests of Reading Philips & Reid, 1982
(Every Six years)
- II. 1990 NZCER PAT Progressive Achiev. Tests Reading
(1986 – 1990) Reid & Elley, 1991
- III. 1973—1985 NZCER PAT Progressive Achiev. Tests Math
Gilmore & Reid, 1986

On the most recent TIMS (1994-5) New Zealand Form 2 Students had a mean score of 50.4 percent (s.e. 0.7%). This value can be compared with those in Table 2.1. On the latest TIMS Singapore edged out Japan as the top scoring country.

Although prior NZ international science test data was 25 years old, subsequent national tests with stability over time could be used as indicators of standings during that time. New Zealand did not participate in an international science study in 1990, but Australia did, and several Australia-New Zealand comparative studies allow Australian performance data to be used an indicator of New Zealand performance.

In 1970 nineteen countries participated in IEA studies in several subject areas. For the age 14 population tested in science Japan was the highest scoring country (Comber & Keeves, 1973). The tremendous margin by which Japan led in math and science could have been recognized twenty-five years ago but does not figure strongly if at all in NZ literature. Japan has several colleges and universities with active education research programs. Kyushu University (Kyushu, 1992) for example has divisions of Science of Education and Psychology of Pedagogy subdivided into units such as Psychology of Problem Solving, Experimental Research, Theoretical Research, Asian Comparative Education, and Western Comparative Education. However, references to Japanese research are scarce in New Zealand education research literature.

In the 1989 SISS Australia (correlated with New Zealand) scored near the mean of countries participating (Rosier, 1990). Other than England, only undeveloped countries scored lower. Japan, Korea and Finland scored significantly higher than all

other participants. Although England scored just barely above undeveloped countries in Africa and lower than Australia, its curriculum documents continued to set the standard adopted. The final recommendation of the ACER was:

“...ideas for the improvement of primary science education in Australia should be based on the practices which applied in England prior to the recent introduction of its national curriculum for science” (Rosier, 1990 pp 189).

If data showing the same significant difference had been for, say, alcoholism cure rates, would the choice have been to follow the methods of one of the *least* successful nations? English curriculum documents were widely circulated during the formation of the current New Zealand curriculum. Even after nearly three decades of Japanese superiority the teaching of that country appears to have been overlooked in NZ research.

The IEA test was subdivided into four major areas: physics, chemistry, earth science and biology. One test lasted 40 minutes and was given to all students. A second test lasted 35 minutes and had two versions given out to students alternatively as an internal check. Extreme care was taken in all aspects of test design and administration. Each question was carefully categorized, pre-tested and designed for universal recognition and low verbal demand. The test and its analysis were planned thoroughly and in great detail (Rosier, 1989).

After 75 minutes of science testing, additional information was collected to enrich the data. This auxiliary information included socio-economic / parental occupation questions, class and school resource queries, math and verbal aptitude samplers, teacher data, classroom-practice questions, student attitude surveys, and so forth.

Correlations (both positive and negative) were shown for numerous variables. One of the most significant high positive correlations was between high SISS achievement and math aptitude. This is not surprising since math is a co- or pre-requisite for physical science and many of the questions were quantitative in nature (Rosier, 1990). Many other factors both inside and outside the classroom were analyzed. For example, did the teacher begin the class with an outline? Did the teacher end the

class with a summary? A negative correlation with high SISS achievement was found in both of these. A neutral or slightly negative correlation was found between high achievement and the use of hand calculators. A positive correlation was found with having a book to take home and high SISS achievement.

The primary population (Population I, 10½ yrs old with five years of formal schooling) was not asked about hours spent on homework. "Students within Population I were not asked about time allocations for lessons or homework because it was considered that their concept of time was not sufficiently developed for them to reliably answer these questions" (Rosier, 1990). Given that 25% of the secondary students (Population II) reported doing no homework at all, and that the maximum reported in science by those who did report doing any was 1.7 hours per week, it could be assumed that primary homework at that time was even less.

Stevenson (1986) noted the decades of Japanese superiority on IEA tests and investigated at what level it began. It was evident by age 10. The earlier it could be found to begin, the less school years could be considered to be a factor at all, and the more parental influence would appear to be a determining extrinsic factor. Stevenson found that Japanese superiority already existed at age six after one year of school.

He formulated several hypotheses to explain the gap. He found that Japanese parents tended to be less well educated than their Western counterparts and could be eliminated as causal factors based on educational attainments. He hypothesized that Japanese children were simply brighter and more precocious. He administered tests of intelligence to different age groups, but at no stage could he find any difference in innate intelligence. Stevenson hypothesized that the Japanese had superior teachers. But he found that their years of training and experience were comparable to other cultures. He hypothesized that Japanese students spent years in preschool prior to first grade, but this did not prove to make a significant difference. He noted that the Japanese school year was longer than most and that the time per day spent on math was longer than most other countries.

He devised a test to eliminate length of time in math education as a variable by presenting fifth year students with problems from three years earlier in the U.S. and Japan. Even when 10 year olds from the two countries were presented with math problems for 7 year olds, the Japanese children proved superior.

Two factors were found to be significantly different in the Japanese sample. One of these could be labeled as the attention span or concentration level of the Japanese students. The students displayed a greater ability to focus on the task at hand (math or other) and to be attendant upon the teacher while the teacher spoke. Whether this was a result of pedagogy or culture was not determined.

Another significant factor was the amount of learning which occurred in the home. From the first day at school (at age six) Japanese children spent an average of forty minutes per day on homework. This time was spent each day, including Saturday and Sunday. Children were assigned homework every day that school was in session and every day it was out of session (holidays, etc.) as well. Homework was an integral part of the Japanese school child's life from day one. Questions pertaining to hours spent on homework in Population I were not part of the last TIMS study in which New Zealand participated, and there was no question about TV watching hours either (Garden, 1996).

In 1995 New Zealand participated in the Third International Mathematics and Science Study (TIMSS) for age 12 students. The results of these studies were published in subsequent years (Garden, 1996). Amongst the 46 nations and 15,000 schools in the performance survey, New Zealand pupils ranked in the middle of the field both in science and in maths.

These results showed little significant change from the results of 14 years earlier when New Zealand school children participated in the Second International Maths and Science Study (SIMSS) in 1981. The results of the TIMSS study placed Singaporean children at the top, South African children last, and the average marks for New Zealand children about half way between those.

In the science portion of the TIMSS, approximately 45% of the total 200 minutes allowed for answering questions was allotted to physical science (Garden, 1996). The remaining time was allotted 45% to Life and Earth Sciences, and 20% to Environment and Other Science (TIMSS, 1996).

The physical science questions were in the areas: *Energy Types, Light, Other Physics, and Chemistry*, and comprised 59 of the total of 135 science questions. In analyzing the performance of Form 2 students in physical science, the results did not differ significantly from those in other areas on the science portion of the test, the average mean score being 47.5% in physical sciences and 52.5% in all others.

Interestingly, the results were in the same mean percent range irregardless of whether those items were in the national curriculum statement or not, and irregardless of whether those items were taught in the classroom or not (Garden, 1996).

As before, additional non-test information and data was collected by the inclusion with the TIMSS test booklets of several questions for the teachers, students and administrators participating. Information was gathered about parameters such as class size, homework hours, teaching methods, study habits, attitudes, aptitudes, gender, socio-economic status, hours of television watched, teacher background and training, and so forth. Statistical analysis of those data has been published in depth elsewhere (Garden, 1996).

Some of this additional information was used to explain the middling performance of NZ students. Examples included the large number of TV hours, shorter homework hours, and comparatively poor study habits (Crean, 1996). However, other factors characteristic of the higher performing countries, such as rote learning methods, repetitive recitation, memorization, frequent vigorous streaming, class sizes of 40 or more, use of student workbooks, minimal individual student-to-teacher time and standardized texts were not suggested as possible ways to improve New Zealand scores.

Information about content material was unfortunately not asked at the time the

TIMSS was administered. However, such data was gathered in the following years from countries world-wide on these and related matters as a separate research initiative in conjunction with the TIMSS (Robitaille, 1997).

Over the same decades that Japan led the world in IEA results in math and science, New Zealand led in reading comprehension (Elley 1993, Philips 1982, Thorndike 1973). When the teaching strategies used for reading were applied to mathematics, significant improvement in test scores was seen (Young-Loveridge, 1993). This teaching strategy was the same one Stevenson noted in the Japanese system, namely structured regular homework from the first day of primary school.

A positive correlation existed between students reading math stories in a home-based preventive intervention program and achievement in mathematics for those same primary school children (Young-Loveridge, 1993). The mathematics stories were drawn from commercial sources, but were limited in number. It has been noted that the number of such resources in science is even less.

Physical science became a formal part of the primary curriculum in 1993, but the results of the 1997 TIMSS for New Zealand were middling. It was therefore appropriate in 1996 to have undertaken a research project aimed at redressing a possible factor contributing to underachievement, namely to create better didactic material. The curriculum could not be taught without teaching resources suitable for teachers untrained in science, but well trained in teaching reading and guiding pupils to use social and creative skills in science learning. This project set out to redress the problem of under-teaching of physical science by providing basic user friendly didactic resources.

2.3 ERO Statements and Reports of 1996

In 1996 the Education Review Office (ERO) made a report on the implementation of the new curriculum. As noted in prior sections, in 1993 the Ministry of Education (MOE) revised several of its Curriculum Statements and *Science* was one of them. The new statement replaced 'Science Syllabus and Guide: Primary to Standard Four' set forth in 1980.

Four Science Strands (Contextual)

The Curriculum Framework outlines the principles followed by New Zealand Schools and identifies the seven essential learning areas, the eight essential skills, the place of attitude and value in the curriculum, and the policy for assessment. Details of the specific knowledge and skills in each essential learning area are published in the curriculum statements.

In Science, there are four contextual strands, including:

- | | | |
|----|---|-------------------------|
| 1. | Making Sense of the Living World | (Biology) |
| 2. | Making Sense of the Material World | (Chemistry) |
| 3. | Making Sense of the Physical World | (Physics) |
| 4. | Making Sense of Planet Earth and Beyond | (Geology/
Astronomy) |

The curriculum statements are intended to provide guidelines to assist teachers to develop learning programs for students that meet the requirements of the curriculum. They are also intended to be broad and flexible enough to allow for local interpretation and elaboration.

In prior years physical science had been taught as separate subjects at secondary school. Science time in primary school had been allocated to biology and geology/earth science. Thus, the Material and Physical World curricula were in many instances additions, not changes to existing prescriptions.

Reports by the MOE on implementation reported that most science time was allocated to the Living World (biology). Biology is traditionally important for an agricultural nation and is also a science in which research had shown young children had an intrinsic interest. It had been taught for many decades and was well-developed and well-resourced.

The least time allocation was for the Material and Physical Worlds (chemistry and physics). This was attributed to lack of teacher knowledge and poor planning by individual teachers.

The following is a quotation from the Education Review Office (ERO) report on implementation of the new curriculum based on an in-depth examination of a large number of schools using several data-collection techniques. (//ERO Publications. Science in Schools. Implementing the 1995 Science Curriculum)

Education Review Office (ERO) “Delivering the Planned Curriculum”:

“This study found a reasonably high level of planning at both school-wide and individual teacher level for the delivery of the science curriculum. What was planned, however, was not always taught.

“While these investigations were undertaken in the first year or so of the curriculum becoming a requirement, the Office might have expected to see more evidence of the new curriculum impacting on the teachers and the students.

“Where a curriculum is planned and not delivered, the issue of monitoring is raised.

“In schools where the planning was not reflected in classroom teaching, senior teachers, heads of departments or principals should have known this and taken steps to rectify the situation. Where delivery was uneven among classrooms monitoring and supervision of teachers should have discovered this.

“It is unlikely that a teacher would deliberately not teach what was required. In most cases poor curriculum delivery would result from lack of confidence with the subject matter or the teaching or assessment approach. Effective monitoring of teacher performance by senior staff would be able to identify both individual and school-wide training needs. Where such performance management does not take place, teachers are left to struggle on unaided to the detriment of student learning in science.

“Expertise in teaching science”

“One of the most significant barriers to the successful implementation of *Science in the New Curriculum* is teacher expertise and confidence. Some teachers, particularly in primary schools, are not yet sufficiently trained in the science curriculum and have an incomplete understanding of it. These teachers find it difficult to cope with the content, planning, implementation or assessment demands of the curriculum.

“The successful implementation of the science curriculum is dependent on teacher knowledge and understanding of the new syllabus. Teacher familiarity with the *Living World* strand is reflected in their confidence in teaching it. All four contextual strands need to be taught, however, and teacher confidence with the content of the *Physical World*, the *Material World* and *Planet Earth and Beyond* strands will need to be increased if all students are to cover the whole syllabus adequately.”

Figure 2.3 shows a 1996 New Zealand Education Review article on this subject. At no point does the ERO report suggest a need for guided textbooks to solve the problem of low teaching hours. The object of this study was to provide books which would increase teaching hours without further teacher training. It was a new and unique idea at the time and a practical, interventionist model of research.

Fig. 2.3 Schools Blinded by Science Curriculum

This article appeared in the 'New Zealand Education Review' July 10, 1996.

This was the year this research project began.

Schools blinded by science curriculum

MANY primary schools have not adapted well to the new science curriculum, according to the Education Review Office.

And the office in part blames the vagueness of the curriculum statement.

"The structure and content of the document do not provide a clear and practical guide to teaching the new science curriculum, particularly for those who are non-specialist teachers of science," says an evaluation report on the curriculum, a year after it was gazetted.

"While schools are charged with providing a balanced curriculum it is very difficult for teachers to know what this means in terms of science and how to provide this balance from the amalgam of strands, skills, objectives and levels presented."

However, the report also suggested that primary schools were not giving science the priority that the government did.

The office investigated 88 schools between September 1995 and March 1996, 20 per cent of them secondary and the rest primary or intermediate.

At least 39 primary schools were not covering all four subject areas of science (now called contextual strands), with a heavy emphasis on 'making sense of the living world' (the old biology).

Reviewers were satisfied in only 31 of the 70 primary and intermediate schools that students were given the opportunity to cover all eight essential skills identified by the education ministry in their science learning.

The report noted that the common approach of integrating science with other subjects required careful planning, which some teachers had an inadequate grasp of.

Nineteen primary and intermediate schools spent less than an hour a week on science, and the vast majority taught it in the afternoon, when practical work was scheduled. Ten schools spent too much time, in the ERO's judgement, on science fair activities.

"It would appear that many do not afford science the priority placed on it by government," the report stated.

Most secondary schools were providing a full and balanced curriculum. Two thirds of all schools had a plan for implementing the curriculum, and large numbers had

detailed planning.

But the report expressed concern that the planning was not extending into practice. Teachers needed more training, and the ministry needed to provide more detailed guidelines on how much time to spend and more practical information on how to teach the subject.

"One of the most significant barriers to the successful implementation of science in the NZ curriculum is teacher expertise and confidence," it states. "Some teachers, particularly in primary schools, are not yet sufficiently trained in the science curriculum and have an incomplete understanding of it. These teachers find it difficult to cope with the content, planning and assessment demands of the curriculum."

2.4 Teacher Training

The science requirements for entry to primary teaching are minimal. Candidates for primary teaching certificates can enter training colleges after completing the sixth form of secondary education (Col. Ed. Bull., 1994). Until recently only junior level general science was required to graduate from secondary school at 6th Form. Most in-service primary teachers have no training in chemistry and physics. Only those trained within the last decade would have been required to take general science to 4th Form level.

Meeting the growing demands for primary science while keeping the minimal science prerequisite for teacher training creates a tension not yet fully resolved. (Burnett, 1959). Students planning a career in primary teaching did not need to enroll in secondary physical science (Min. of Ed., 1993). Students who tried those courses and failed, might have subsequently decided on a career in primary teaching where such a failure would not be a hindrance (Min. of Ed. 1993). A general disinterest in science on the part of the teacher can undermine the grounding in the subject critical to the student (Comber, 1973). Primary trainees who have tertiary degrees rarely hold them in physical science (NZ Dept. Stats, 1993).

A few primary teachers may have an outright aversion to physical science, and avoid it, focusing on other areas such as biological science, language, art, and music. There may also be a simultaneous aversion to math and physical science may suffer when there are math deficiencies (Rosier, 1990). The career choice of primary teacher may have been based on the minimal science requirement. Many may prefer teaching in areas of greater subject strengths, and plan class time accordingly.

Primary teaching is a career path in academia where science in general can be completely side-stepped and those who have gained positions of authority may

overlook the problem or have weak or faulty understandings of it. There may be a sense of security with the status quo. There may even be complacency and subsequent resistance to curriculum innovations in this unfamiliar area (Burnett, 1959).

Primary teachers are generalists, but would not normally be expected to implement new curriculum areas in which they themselves are not grounded. Lesson plans, activity schemata, information sheets, etc. would not normally be devised by teachers lacking the time and subject knowledge for such course development (Linehardt, 1990). A teacher with a full schedule of teaching, activity sponsorships, monitoring, custodial and clerical duties, committee meetings and other school assignments could impair their effectiveness by doing this extra work.

The lack of familiarity with a subject may create discomfort for the classroom manager during that lesson, compounding the problem (Neale, 1985). The unexpected question or event may quash the enthusiasm of the teacher and end further trials in science teaching. Constructivist theories may distort to avoiding student questions and instead of inspiring, explanations may be incomplete, evasive and inaccurate.

Teachers who have not learned a subject may hold misconceptions about the nature of learning that particular material and perpetuate the mistakes which caused them to turn from it as students. A teacher's attitude toward the way material can be learned may affect how the material is taught (Anderson, 1980).

The skills and training of the primary teacher as facilitator and generalist can be used to the advantage of the student if pedagogical direction and didactic tools are at hand. External support is useful to both the teacher and the student when unfamiliar curriculum areas are introduced (Anderson, 1985; Neale, 1990).

It seems obvious that to work within the current teacher training system one solution to the problem is to create the user-friendly teaching materials that will enable anyone, even an untrained home school parent to teach the new physical science curriculum. Specialist science teachers can also be trained, but would normally have a place only at intermediate schools, not full primaries. In either case, good didactic material is necessary and in 1996 there was a need for such material.

2.5 Pedagogies

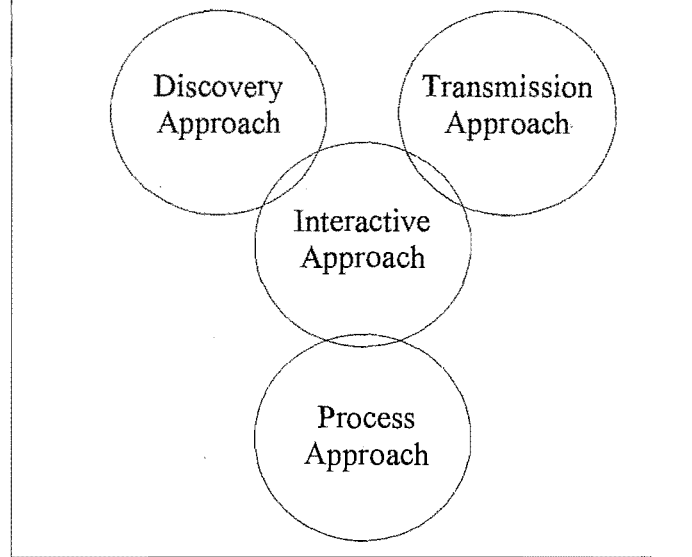
New Zealand has been productive in developing methods of teaching primary math and science. A pedagogy developed at the University of Waikato for teaching primary science and used in schools for many years is simply called the 'interactive' approach (Biddulph, 1985). This method embodies and encompasses three primary learning methods: discovery, process and transmission. It refines them and adds interaction for applications in the domain of the elementary child and the elementary science classroom (Osborne, 1985; Bell, 1993).

In this method value is placed on the child and the ideas of the child. This expands confidence and further empowers the child to 'own' his learning. It allows for open-endedness to encourage and stimulate intellectual growth. The process confirms the validity of question as opposed to answer for learning. It establishes learning pathways for dealing with complexity and ambiguity. Things are often not straight-forward in physical science, and it is useful for pupils to be comfortable with complexity and ambiguity in some phenomena (LISP(P) 1985).

While the life sciences can be taught in a fairly straight forward 'show-me' way at the primary level, physical science involves concepts which sometimes cannot be seen. Some things are small, such as atoms, some are large such as moles. Some can be described and measured, but are relatively intangible. Some of the concepts are counter-intuitive. The interactive approach is a teaching strategy which is particularly useful for teaching physical science at the primary level (LISP(P) 1985). By the tertiary level a greater proportion of purely transmissionist teaching is more appropriate.

The methods overlap and compliment each other as Fig. 2.5 shows a Venn diagram of four approaches to teaching science (adapted from the LISP monograph).

Figure 2.5 Four Approaches to Teaching Science
(LISP(P) b1985)



A negative correlation was found between passive watching of ‘magic show’ type demonstrations, teacher demonstrations and ‘Mr. Wizard’ type lectures (Roadruck, 1993) and student achievement, although gender was not controlled.

Even a quiet activity was found to have a greater positive correlation with learning than passive watching. Students were found to learn ‘better’ when actively and personally involved in some way and doing things for themselves, even if it was a ‘quiet activity’ such as reading (Bodner, 1986; Gabel, 1989; Ward, 1993).

Student *activity* is the key in many studies. Activity ranges from closely guided assimilation to open-ended and child directed (LISP(P)1985). Lecture *per se* has a low priority (Ward, 1993) for primary children. No lecture at all, and activities which do not exceed 30 minutes, are easy to set up, can be taken down with no clean up, have simple and clear explanations and are teacher-friendly are items which have all been correlated with positive learning outcomes. A ‘Bernoulli’s Principle’ practical, for example, met all criteria except that it could not be explained simply so was dropped. Asking students to solve a puzzle could lead to frustration and could be counterproductive (Ealy, 1994).

Although most approaches use active learning in the classroom, the type of activity

was variable. It was suggested in several studies that 'Teaching labs should mimic the process of scientific discovery' without clearly defining that process which in fact can be routine, tedious, repetitive and often fruitless as well (Gabel, 1989). Gabel (1989) also showed that teachers should have information guides with anticipated questions and answers. Any lab activities should be suitable for a variety of conditions, materials, and student abilities and students fared best when given worksheets to fill in.

Teachers found it useful when science was broken down into major components for organizational comprehension. They preferred doing straight forward activities with little or no theory, and following a process (e.g., make a cake) rather than specific tasks (mix egg and flour, then heat). Teachers did not want to deal with 'scientific facts' per se, but scientific processes (Davis, 1990). Overall, elementary science was perceived to work best if activities did *not* involve figuring out a preconceived answer, particularly the 'right' answer that everyone must 'get' (Bodner, 1986).

A negative correlation was found with assessments, asking students to explain things to other students, tests, strict schedules and framework explanations (Freilich, 1983). A positive correlation was shown with good, logical information, teacher confidence and knowledge, questions answered clearly, prompt feedback on work, variety and repetition of the same types of problems.

The term 'concrete operational' (Piaget, 1954) describes what a general consensus found most important: the need for primary students to experience such concepts as volume and distance as much as possible in a real or concrete way.

A written symbol is concrete for a primary student. But, putting marshmallows on the ends of toothpicks to represent molecules, although concrete in a sense, was found to generate more misconceptions than correct understandings. Therefore, discretion in using teaching aids and analogies was found to be critical (Roadruck, 1993; Swinehart, 1987).

Building on the skills, concepts and procedures already learned and reinforcing

previous work by connecting it to new work are useful techniques (Church, 1999). Writing something on paper, using the hand with pencil (not mouse) was another aid in 'getting a feel for', or conceptualizing and reinforcing what had been learned. *Speaking* about the work and verbalizing concepts also helped to clarify understandings.

Especially important for primary pupils is a positive experience overall and an environment which fosters self confidence. Clarity and simplicity are the keywords for the objectives and concepts introduced. Any activity which required the student to 'think' had to be handled in the most non-threatening way or could lead to total frustration instead of learning (Ealy, 1994).

"Figuring things out", solving novel puzzles, being clever, as well as being challenged to 'think' could all be debilitating to the student (Ealy, 1994). This meaning of 'to think' is not the same as the meaning 'to reason' or to 'explore' or to 'make sense of things' -all of which have been shown very productive means of conveying science learning (Bell, 1993). In many studies the emphasis was on building on the student's understandings, not expecting 'answers' which only a small percent may produce (Biddulph, 1985).

A positive correlation was found with a long length of time allowed for concepts to become assimilated before being manipulated and used, that is, with early introduction of ideas prior to their application in the secondary classroom. Thus, evaluation is not a short-term process. Times of up to three years were needed for concepts such as the particulate nature of matter to be assimilated (Rowe, 1983). Even after three or four years from the first introduction of such a concept, during which time it had been revisited and re-used in different ways, it could remain in one 'register' for class use and test taking and in another for everyday living.

Some gender differences were noted with respect to processing information. For example, where males might understand through building apparatus, or preparing chemical reactions, the female activity might involve reading about the apparatus or writing or speaking about the reaction to grasp the same principles (Wilson, 1995).

Gender effects were also noted with respect to contextual translation of sentences into algebraic equations (Niaz, 1991). Virtually all studies agreed that the primary student must be an active learner and virtually all embraced the tenets of constructivism in some form (Bodner, 1986).

The roots of constructivism are found in studies on language development and the gradual construction of meaning through connecting words in sentences (Piaget, 1926). The child would not have been expected to construct or develop or discover his own alphabet or words. These were absorbed and taken from the environment, from the context, and taught and learned in a specific age-related window with the 'fervor associated with the instinct for survival' (Kozot, 1985). The same is true of science. If the language is available in the environment the pupil can more readily absorb it and learn enough of the 'vocabulary' and other building blocks to form 'sentences' with purpose and meaning.

It is clear from the teaching methods developed in the last forty years that various approaches need to be incorporated in any teaching material in order to encompass several learning and teaching styles. The basic content needs to be presented using these methods which have been developed for primary learners.

2.6 The Science of Teaching Science

Primary science came under increased scrutiny in several countries in the 1980's and 90's (Biddulph, 198; Jorden, 1990; Neale, 1990; Richards, 1983; Smith, 1989; Tisher, 1983; US Dept Ed, 1983). Attention focused on both the content and methods and the latter paralleled developments in cognitive psychology (Ausubel, 1978; Resnick, 1983; Von Glasersfeld, 1984). As stated by one of its foremost authorities Ausubel, (1978) "*The most important single factor influencing learning is what the learner already knows.*" Primary science is what the learner will 'already know' in high school so the implication for it is profound. A problem for students of any level is the lack of sufficient prior knowledge with which to make sense of and order the new information received (Helm, 1983). Various terms have been assigned...alternate constructions, misconceptions, or the total lack of any conscious constructions at all contribute to the confusion and frustration and to the common perception that 'science is hard' (Byron, 1998).

A teacher can lay the groundwork by articulating, pointing out, and giving substantive meaning to the obvious, but, if the general emergence of quantitative abstract thinking has not occurred in a timely manner in the appropriate stage the acquisition of new knowledge may be impeded (Page, 1960). Theorists have postulated a critical age-related phase transition in quantitative and abstract thinking which has a high intensity and then diminishes and is followed by qualitative, cumulative and experimental stages in such a way that any one stage cannot be revisited (Piaget a 1928; b 1954). These observations and theories support the early introduction of quantitative concrete and abstract subject matter.

Each subject has particular teaching language, methods, etc. associated with it. This is true to a great extent in the physical science where there is a co-requisite of math, special language and symbolism (Dierks, 1985; Ozsogomonyan, 1979; Ver

Beek, 1991). A direct correlation was shown between years of reciprocal knowledge and understanding of contextual matters in physical science. The strength of association increased if the reciprocal knowledge was age- and stage-appropriate (Stavy, 1988). It is thought that only a limited number of new 'bits' of information can be processed at a time in short-term memory and by early post-primary (i.e., Year 9) or late primary, students who do not possess the *reciprocal personal constructions* for science learning may exhibit boredom, lack of interest or outright aversion and either drop out or try to avoid it.

Much research has focused on learned misconceptions and their consequences (Osborne, 1985). Prior to this groundbreaking research, failure was 'swept under the rug' rather than used as a pedagogical tool for improving teaching. Before the enlightening work of Osborne, Driver and others, the greater the failure of the students, the more purely transmissionist became the teaching strategies. Misconceptions could become even more firmly embedded (Driver, 1985).

Early misconstructions can persist from middle school through post-tertiary, post-graduate courses, and students learn to mask conceptual discontinuities by rote learning and manipulation of symbols to advance scholastically. Graduates with a B.Sc. in chemistry who had completed 500 lecture hours and 400 laboratory hours in chemistry were shown to have managed to hold firmly onto their inappropriate constructions ('children's science') (Bodner & Domin, 1995). In fact, these students would re-describe reality if it did not fit their personal constructions of that reality rather than let go of a misconception held since childhood.

Briefly, in the cognitive model students are not blank slates in vacuo, but active selectors of information. The process is cyclical and emergent and dependent on feedback and selective incorporation of new ideas. The cognitive model of learning has been of value to science teaching and is now grounded in decades of research data compilation. Cognitive structures are viewed as starting from 'bits' such as words, e.g., 'atom' and developing into elaborate coherent understandings of complex arrays of meaning, e.g., 'atomic theory'. Misconceptions are concepts that differ from the accepted understandings. Cognitive structures are interdependent

and integrated, and misconceptions are considered weak points in the overall structure. Like many learning theories preceding the advent of artificial intelligence, cognitive theory is replete with biological symbolism and words such as maturation, adaptation, evolution, growth, process, levels of attainment, accommodation, etc. Some of the early work in cognitive theory was done in the acquisition, organization and use of *language*, so that the construction of meaning in sentences could be seen as developing as a growing organism would develop—seamlessly and organically. Structures could be viewed as growing and developing in a continuous manner to a final state of relative perfection. The organic approach did not provide insights for deleting bad data or erasing errors and ‘starting over’. The term ‘construct’ was used to indicate a natural development.

The roots of constructivism extend back to the early 1700’s. It was developed last century by Piaget and others, reaching a ‘point of invariance’ or relative completeness in the late 1960’s. Observing a human infant, Piaget (1926) wrote,

“...When language and thought begin... he is in a universe that he has gradually constructed himself....”

The universe exists as constructed in the framework of the child, by that child in a way important to that child for its survival. No one else can do that for him. From this view, knowledge is not transferred from the mind of the teacher onto the mind of the child waiting passively. The child is viewed as grabbing knowledge whenever it can from surroundings, including from the mind of the teacher if that is available.

The construction of knowledge is, from this view, an act which is reflexive, intuitive, inborn, and a natural instinctive means of survival. It involves an interaction between the pupil and the environment. It has served as a useful theory along with many others in cognitive psychology for understanding learning and teaching in the classroom (Atkinson, 2000).

The didactic material developed for this project followed these principles and encouraged learning and revisiting ideas without requiring any ‘right or wrong’ answers or testing of pupils.

2.7 Materials

This section presents a rationale for investing in the production of books. Since the majority of primary pupils are visual learners, if a picture is worth a thousand words, then a video or interactive computer program could be worth millions. It has become necessary to justify the production of basic classroom workbooks.

The purpose of this study was to redress one possible factor contributing to the relatively weak performance of New Zealand students on the physical science portion of the TIMSS. It was hypothesized that a dearth of instructional material for Years 5-8 in physical science could retard the potential of students in this subject and contribute to a gap between students who would and students who would not be positioned for compensating opportunities outside the classroom, opportunities generally related to socio-economic factors. It could explain discrepancies between the intended curriculum, i.e., the formal curriculum statement, and the implemented curriculum, i.e., what was actually taught in the classroom (Robitaille & Maxwell, 1996). It could be a contributing factor to the lack of confidence some teachers expressed about teaching in this subject area as well. In short, better, more user-friendly classroom books could increase teaching hours in the subject.

However, books are only one of several possible resources which could have been made. Nowadays there are several choices. For activity-based learning which involves interpreting illustrated instructions, reading new vocabulary words, and recording data and observations, a write-on book would seem to be a good starting choice. Where WebPages exist and can be downloaded or mastersheets photocopied, they still have to be originated or, if copied, the end result is still the written, paper-based text format with the additional drawback that time is required to find, scrutinize, and select appropriate pages. Whats more, the final selection may be hurried, lack discretion, or be haphazard and incomplete. For classroom use, time and costs are involved in downloading and photocopying handouts.

Interactive computer programs are of unquestioned value. But inequities may exist amongst users' background and training or to the availability, quantity and quality of computer equipment at any given school. The diversity in schools with respect to IT equipment means the playing field may not be level (Lauder & Hughes, 1990).

There is evidence that children learn certain meanings in 3-dimensional space which cannot be replicated cyber-space. The effectiveness of interactive computer programs may be enhanced by the artificial addition of ordinary classroom stimuli such as pre-recorded teacher talk, pre-recorded overheard peer discussion, pre-recorded overheard peer discussion of wrong answers and mistakes, and so forth (Cox, McKendrie, Tobin, Lee & Mayes, 1999). This indicates the importance of traditional person-to-person classroom stimuli and real-life learning and teaching processes (Tao, 1999).

Videos are excellent teacher aides, are invaluable for audio and visual instruction, have been shown to enhance learning, and are highly recommended for many purposes (Ayers & Melear, 1999). They would not normally be convenient as the main resource for teaching the formal syllabus. Books are more readily available, and do not require extra equipment. Ideally, text material is augmented with video.

Historically, textbooks have played a vital role in the teaching and learning of science subjects (Collette & Chiappetta, 1989; Thiele, Venville, & Treagust, 1995). The book market is competitive, and the school book market hopelessly so. The financial drawbacks to developing new textbooks are magnified in a quasi-market school system such as in New Zealand for primary and intermediate grades. A quasi-market system is a hybrid institution which combines public financing and market regulation (Vandenberghe, 1999). Development costs to research, write, illustrate, print, trial and market even one title can easily reach six-figures

There may not be much incentive in the private sector to develop new text books (Dei & Karumanchery, 1999). There can be resentment, rivalry, plagiarism, competition and even sabotage anywhere along the line. Where schools compete for students, teachers who are expected to produce their own materials are put

under extraordinary pressure. The resources developed in these conditions are not ordinarily shared (Private Comm., 1999, 2000).

Nevertheless, the overall benefit of textbooks to society is high. Chiapetta, Sethna & Fillman (1991) suggest that science textbooks assist in the development of a scientifically and technologically literate society. Certainly this is true if such books give primary-aged pupils the opportunity to practice the methods of inquiry and the disciplined thinking skills of the physical sciences, as well as building the foundation for secondary courses in these fields. Such skills include inductive and deductive reasoning, methodical problem solving, observing and recording, qualitative understanding of principles, and the ability to handle quantitative relationships (Wilkinson, 1999). Scientific literacy today stresses a balance of knowledge, investigation, thinking and application (Hurd, 1998).

A pre-secondary text can also provide opportunities to build broader skills such as communication, cooperation, and organization (Vygotsky, 1978). A good text can incorporate and exceed the requirements for the both the contextual and the integrating strands described in the national curriculum statements (MOE, 1994).

A basic framework for constructing meaning and understanding in the physical sciences would include local real life contexts and where possible, examples of the interaction between science and the pupils immediate environment (Bybee & Ben-Zvi, 1998). This is especially true in a bi-cultural nation such as ours where the inclusion of examples in both English and Maori can serve broader educational policies (Johnston, 1999).

Students can learn by doing practical work in science. Content can be presented in association with activities which guide students in direct experience and experimentation (Dewey, 1938; Stone, 1995). The material should allow teachers to use a variety of classroom management techniques (Fogarty, 1999). A student text/workbook which is clear and well-illustrated so that a student can read the material independently should satisfy the above criteria.

The generative learning theory for science education formulated by Osborne and Wittrock (1983) asserts that knowledge is constructed when learners attend to new sensory information and generate meanings in light of what is known. Writing-on, drawing, discussing, annotating, tabulating, and so forth are processes through which raw experience can be infused with scientific meaning and are activities which aid in the retention and comprehension of concepts as well (Anderson, 1999). A write-on workbook can well serve the process of making meanings more concrete (Gardner, 1983; Piaget, 1970).

The content should be as accessible to the first-year or home-school teacher as to the teacher of many years experience (Carter & Richardson, 1989). It should be adaptable to any teaching method with which the teacher feels comfortable, group learning, peer instruction, interaction with text, apparatus or lecture, or any other teaching strategy or combination of strategies (Swartz, 1999).

Conceptually difficult knowledge occurs commonly in the physical sciences which are replete with paradoxes, inconsistencies, counter-intuitive phenomena and subtle distinctions, such as between weight and mass, power and force, temperature and heat (Perkins, 1999; Thomas & Schwenz, 1998). Everyday words, such as 'work' and 'energy' have special meanings and definitions (Featherston, 1999). Whereas certain phenomena might be obvious, observable and even measurable in other sciences, they may require testing and extending mentally 'to infinity and beyond' in the physical sciences (McCloskey, 1983; Clement, 1993).

It would be counterproductive to require extensive physical science knowledge as part of the professional working background of pre-secondary teachers. It is sufficient at the pre-secondary level to teach the core formal curriculum and skills in the subject (Kwon & Lawson, 2000). Of course, teachers are encouraged to expand upon it when possible. A textbook 'owned' by the pupil, equipment, a teacher guide with explanations, answers, practice sheets, suggestions, videos, etc., all should help to make the physical sciences as uncomplicated to teach as any of the teacher's other subject strengths.

Professional publications assist the teacher and the pupil by sorting and presenting concepts which are basic to the formal subject matter and appropriate for the grade level. An age-appropriate write-on format could aid the pupils' understanding by physically interacting with the text, using hands to express thoughts on paper, and making his/her own inscriptions on each page (Klein, 1999).

It is probable that one of the factors operating in a quasi-market school system is the path-independent nature of learning (Higbie, 2000). This may be at odds with requirements which dwell on defining the path. Students are expected to take control of their own learning and their caregivers are asked to become involved as well, and yet there is a strong reliance on those in authority to validate the process.

Whether there is or is not limited teacher background knowledge an appropriate book which a student can refer to, take home, show caregivers, and read ahead in if interested, gives as much control as possible to the pupil. When a new subject is introduced or needs to be introduced without ambiguity, elementary teachers tend to rely heavily on textbooks (Robitaille & Taylor, 1997).

In 1997 an encyclopedia of the education systems participating in the TIMSS was published as part of a research initiative of the International Association for the Evaluation of Educational Achievement (IEA), the organization which conceived and supported the TIMSS. The three top-scoring TIMSS countries all have used the student workbook format for the last decade or longer.

Each country was profiled for the same information. For example, under 'Science Curriculum and Pedagogy' subheading 'Science Textbooks' was a general description of our classroom practices:

'Textbooks are more often used to support the classroom program than as a basis for the program. The use of multiple print resources, including topic books and articles, in addition to one or more set textbooks is the mode.'

'Modern resources tend to be more appropriate to the developmental levels and learning needs of students. They are more readable, colourful, pictorial

and have less dense text. Links between science and technology are more explicit.'

'It is unusual for primary schools to issue science texts, especially to Population 1 (age 9, 10) students, and teacher-produced materials and topic-specific booklets are common' (Garden, 1997).

It should not be deduced from this that a text is only a hardbound book of significant length, dense text, not pictorial, not colourful, old, written at an advanced level, not readable, not appropriate to the developmental levels and learning needs of students, showing no links with either modern science nor technology, and used only as back-up reference material by teachers. A student text/workbook which is complete with spaces for recording data and doing calculations as well as writing and drawing and expressing ideas can introduce pupils to correct methods of data handling as well as save time, and help keep the focus on the activity at hand (Keys, 1999).

'What counts in particular disciplinary contexts as convincing arguments or persuasive results is inexorably tied to the practical devices through which phenomena become accountable' (Lynch, 1995).

If, as Niels Bohr suggested,

"The task of science is expanding our experience and reducing it to order ...then reading, writing and discussing are the mechanisms through which raw experience can be transformed into data, models and theories, and infused with scientific meaning (Anderson, 1999).

Our science teaching practices might be enhanced if pupils had the resources to support meaningful interpretations and constructions of their world and to expand their ability to reduce it to order (Roth, Bowen & McGinn, 1999). A text for pupil and teacher and guided workbook could mitigate the problem of under-teaching.

2.8 Content: What Should be Taught?

This section gives a review of content from different perspectives.

How is it possible to bridge the gap between the world of modern physics and chemistry and the world of childhood and simple abilities? How can the 'comfort zone' of the primary teacher be extended include physical science (Scottish Ed., 1965) ? What facts, skills, attitudes and concepts are appropriate?

Children are natural scientists in many ways. Exploration, hands-on, literally 'grabbing' opportunities to learn, trying new things, asking lots of questions, etc. are components both of science learning and of childhood. How is it possible for the educator to encourage and develop those desirable qualities children bring naturally to the classroom into the study of physical science (Perkins, 1986)?

How is it possible to maintain enthusiasm and support if a teacher feels uncomfortable with the subject matter and would rather not teach it at all than teach it poorly (Lind, 1992)? What effect does a proper foundation have on both the teacher and student? Why do so many late primary students express a keen desire to learn science and 'grow up to be scientists' only to 'hemorrhage out of the science pipeline' at the early secondary stage (Bodner, 1992)?

A great deal of research and analysis has gone into these questions over the last two decades (Finster, 1989). Two general approaches which emerge may be called generic and specific. Generic approaches look at general unifying concepts. Specific approaches analyze items or bits of knowledge and the teaching of these.

An example of a generic approach might be the incorporation of measurement skills into several general lessons to foster quantitative skills, manipulation of and description with numbers.

A specific approach might be to measure the weight of an object, for example, with the focus being on the object and its exact weight rather than the general skill of taking and recording data, and the use of that measurement in context.

Because of the time-lag from the introduction of a skill at primary school until its application in secondary school (three years or more), some research uses retrospective analysis (Polgar, 1995). That is, the work of a sample of secondary students is matched with the activities in their primary school curriculum and hypotheses made based on any correlations found.

In the last few decades research has focused on the teaching of science through the development of a coherent system of ideas. Although extant in practice, the notion of science as a catalogue of facts to be memorized has long been rejected by the research community (Driver, 1985).

Several excellent programs have been trialled as teaching items in recent years. One designed for late primary is the “Scientific is Terrific” set of units from the University of Millersville (Millersville, 1965). Another such set is the University of California, Davis Northern California Science Project (UCD, 1966). A third is the College for Kids – Consider Chemistry program developed by the University of Wisconsin which has applications for all levels from New entrant to Form 2. Topics include ‘Biochemistry’, ‘Energy changes’, ‘Behavior of Gases’, ‘Polymers’, ‘Compounds,’ etc. (Univ. of Wisconsin, 1995).

Other approaches, such as the Salter’s Approach use ‘in context’ themes to teach science (Salter, 1994). For example, ‘kitchen’ chemistry or ‘forensic’ chemistry employ a familiar central theme to introduce science concepts which may be taught in that context.

In general, the activities of any approach are dictated by those which will be done in secondary school which are in turn dictated by university entrance exams (Carlson, 1987). The New Entrant who mixes vinegar and bicarbonate and gets fizzing is doing stage-one physical science (Kelter, 1988).








One of these projects is outlined in detail to show the depth and extension possible with a deceptively simple topic such as the well known 'Floating and Sinking'. The project included physics, chemistry and geology and was established as a generic guideline for a teaching approach to use at any primary or secondary level.

The UCD Northern California Science Project was established to train students in the use of their senses and to use observation as the basis for teaching the language, fundamental concepts, factual information and problem solving which are part of physical science education. Three interdisciplinary topics were outlined: electromagnetic radiation, crystallization, and buoyancy and density.

The areas for discussion pertaining to buoyancy and density included the physical laws governing a solid floating in a liquid, the meaning of density and specific gravity, the measurement of density, the use of the concept of solids floating on liquids, the structure and properties of water, types of ice, systems where the solid is more/less dense than the liquid, hydrogen bonding, hydroxide ions, etc.

Since observation was used as the teaching vehicle, the students were asked, for example, to observe a glass of water containing several ice cubes for several minutes. They were allowed to work individually or in groups of up to six. They were asked to record every question generated from their observations.

Some of the questions the pupils generated spontaneously included:

-  Why is ice opaque and water clear?
-  Why does solid water float on liquid water?
-  Why is the ice partially submerged?
-  Why does the exterior of the glass get covered with water?
-  Why is there less solid water as time passes?
-  What causes the solid water to melt?
-  Does the volume of ice + water equal the final volume of water?

The basic vocabulary introduced to discuss and answer these questions included: *solid, liquid, water, fluid, heat, temperature, melting, freezing, acid, base, phase,*

heat capacity, etc. Symbols were introduced at every opportunity and equations were written for solid-liquid equilibria. The students were further challenged by being introduced to overarching concepts such as the following:

1. Molecular Structure

- Formula and structure of water
- Three dimensional relation of oxygen and hydrogen
- Electron density
- Hydrogen bonding (in solids v liquids)
- Acid-Base interactions

2. Equilibria

- Heat gain/loss in solid/liquid system
- Heat needed for phase change
- Temperature change for specific masses solid/liquid
- Calculations on above
- Making and breaking of bonds
- Bond energy
- Enthalpy, entropy, order/disorder

3. Dynamics

- Rate of movement to equilibrium
- Factors affecting rate
- Surface, stirring, diffusion
- Dynamic v Equilibrium
- Kinetic processes, factors affecting them

These units and guides are good examples of material and methods which can be used to teach primary physical science. There is an unlimited pool from which to choose material. However, most structured primary courses lead on directly to the courses or tests at the secondary level. In the States testing is done by Scholastic Aptitude and a wider number of conceptual topics is undertaken. In New Zealand for many decades the topics were limited to those which recurred on School Certificate exams, so were more specific in nature and did not include topics such as ideal gases which, though important and interesting, would not appear on the tests at secondary level.

2.9 Skill Categories

Certain skills are associated with achievement in physical science. Mastery of these skills can lead to improved performance in physical science. One is the use of special language. Language in this context includes, for example, what some have described as the ‘alphabet’ - the 103+ symbol periodic table of the elements (Lerman, 1986; Markow, 1988; Nakhleh, 1992; St. John, 1989). In addition ‘words’ comprised of ones with meaning particular to physical science (e.g., Avagadro’s Number, Maxwell’s Equation) and words with several meanings outside physical science but with specific meaning inside it which must be mastered (e.g., reaction, work, force). The grammar and sentence structure may be considered the way in which all the different parts are put together in a regular way (Markow, 1988).

The average textbook for a course in introductory general chemistry has been shown to contain an average of fifteen symbols per page and overall more new language than would be taught in an introductory foreign language course taught at the same level (Makleh, 1992). Much of that language barrier could be reduced if the language were introduced earlier at the primary level, an appropriate age for hearing, seeing and learning new language (Piaget, 1926; 1954). Students may be overwhelmed by the new language in addition to the new concepts if both are introduced at the secondary level. This is particularly true in a subject such as organic chemistry where many students do not ever get past the nomenclature (Libby, 1991; Sands, 1993).

Elements of the ‘language’ can be taught in several different ways—art, story, etc. (Finster, 1989). Students may in this way learn the science without seeming to be doing science. Games or projects in art which involve the elements (alphabet) or other symbols have been shown to be reasonable pedagogical tools for science

content (Lerman, 1986). History projects, writing assignments, individual reports centered on the elements and chemical symbols have all been shown to be sound, non-threatening ways to cover the foundations for more advanced science (Battino, 1983; Pickering, 1993; Scoffern, 1848).

A second important skill is observation. The ability to observe carefully, to record observations using different methods, to assign meaning or rational order to the observation and to observe in different ways are skills which can be learned. Careful observation may include discussion, measurement and recording. How far will a ball roll on a frictionless surface (Galileo, 1687)? Will a ball thrown upward return to the thrower with the same speed and acceleration (Newton 1687)? What is signaled by odors, colours, textures, sounds, etc? Observation skills can be nurtured and refined from the earliest grades. The Northern California Science Project described above was established to, amongst other things, train students in the use of their senses and skills in making observations.

A third skill distinguishing quantitative from descriptive sciences is numeracy and measurement. Lord Kelvin (Kelvin temperature scale) put it succinctly :

*“When you can measure what you are speaking about,
and express it in numbers, you know something about it.”* (Schaum, 1958)

The use of numbers, the language of mathematics, the symbolism of mathematical notation, and the application of mathematics as a tool (not an end in itself) are skills correlated with physical science achievement. Quantification, numeration, estimation, measurement and general use of numbers outside of formal math classes is a good background (Stevenson, 1986). Where the math curriculum lags or is poorly taught, the burden on the physical science student and teacher is high (Stevenson, 1986; Min of Ed (a)1993: (b) 1993).

Problem solving often involves mathematics, but it is also important to practice this skill in non-mathematical contexts. Problem solving can be practiced qualitatively where no numerical solution is sought. This is important in concept learning where the “only one right answer” syndrome is counterproductive and in situations where math skills lag behind the science concepts (LISP, 1985).

Another valuable skill in physical science is the ability to define abstract concepts on paper and thereby make those concepts more concrete. This can be done by talking, drawing, by writing words, by setting up equations, by using numbers, and so forth. Abstractions such as states of equilibrium or things one cannot see with the naked eye such as atomic structure can be represented on paper in a way not common to other subject areas (Genyey, 1983; Nakeh, 1993).

Students frequently need to be able to diagram both the concrete and the abstract parts of problems as the first step in finding solutions (Osborne, 1985). Drawing a reasonable representation of an idea, a system, a fact, etc., is an important skill necessary to clarify and define the problem as well as to order the problem for further information such as the assignment of numerical values.

Practice with conceptual- and calculation- problem solving is of benefit in introductory sciences (Niaz, 1991). An alternative to expressing problems visually is expression in language, either grammatically or numerically, in symbols and equations, or in graphics such as the use of language in the technique of concept mapping (Beall, 1994; Noval, 1984).

Whatever technique is applied, the paper chemistry becomes the concrete chemistry, the paper physics the concrete physics, e.g.,

- Draw the Bohr model of the Lithium atom.
- Masses m_1 and m_2 are arranged at either end of a pulley system with m_1 on a smooth frictionless incline of 0° and m_2 suspended freely on the opposite side of the massless pulley. Determine the acceleration of the masses. Draw the setup. Show and label the forces.

Retrospective studies are those in which the primary school activity is compared with secondary achievement to determine what might have provided an advantage in secondary years. Other external variables such as parental influence, socio-economic status, etc. can be accounted for as well. High positive correlations were found with math skills, prior coursework in physical science, measurement skills which had been practiced frequently, and problem solving ability. Interest in science or enthusiasm for it were not predictors of achievement. Low math ability was

shown to be a predictor of risk in general or introductory physical science.

Skills which affect secondary physical science competence include:

- Competence in pure mathematics.
- Ability to using applied math and numbers to describe things.
- Familiarity with good measurement skills, techniques, measurement logic.
- Prior good quality physical science instruction.
- Experience in transposing abstract ideas to paper, using paper science.
- Familiarity with special language associated with the subject.

These are skills which a teacher with no science training can teach. Measurement practice, naming elements, expressing abstract ideas on paper, etc. can positively affect the students' success in physical science.

In 1996 many of these ideas were contrary to accepted primary science practice. It was felt at that time for example that vocabulary should be kept to that the child already knew, and math should not be included in science. However, based on this literature search didactic material for primary science should incorporate opportunities to learn and practice these skills. It should introduce new vocabulary, give opportunities for drawing or writing abstract ideas on paper, require measurement and math skills, provide clear physical science concepts and so forth. The material made for this project did incorporate the findings of this chapter and did allow pupils to learn and practice these new skills.

2.10 Summary of Chapter 2

In this Chapter 2 some aspects of a situation as it existed in 1996 when this project began are described. In Section 2.1 we defined physical science and showed that it was not a formal requirement in the national primary curriculum prior to 1993. We showed an example of the type of material then available from which to teach and it was clearly outdated, inappropriate and needed to be improved.

In Section 2.2 we showed that the performance of New Zealand primary students on international tests in the subject was mediocre and lower than would be expected for a country with one of the highest standards of living and best educational infrastructures in the world. We found that one factor common to pupils in the high performing countries was having a book to take home and performance in science improved when students had science books to read.

In Section 2.3 we showed that ERO reports of the day said teaching hours of physical science were unacceptably low and that teachers were to blame for under-teaching physical science.

In Section 2.4 we showed that teacher training did not require much science background, especially for teachers who had been trained a few decades earlier.

In Section 2.5 we described some teaching methods which had been developed in New Zealand in part to help teachers teach science when they had no science background, and in Section 2.6 we described some teaching theories that were popular in the mid-1990's for teaching science.

In Section 2.7 we showed the need for books to mitigate the problems of under-teaching and poor test scores. In Section 2.8 we looked at the type of content which

needs to be part of a primary physical science text and in Section 2.9 described the skills which have been shown enhance physical science learning and which should be incorporated in didactic material.

In 1996 many of these ideas were contrary to accepted practice and theory, and at that time all of these ideas needed to be explained and justified as they have been done in this literature review.

At the time of this literature review and at the time of the pilot study and book survey we were searching for material to adapt for the New Zealand schools and had several samples from North America and Europe, but none met all the criteria we had outlined in the literature review and that we sought. We had received material from Asian countries, but most was in the native language and the translation costs were prohibitive. It was not until the following year that we obtained text material from the country which had scored highest on the TIMSS (Singapore) and were delighted to find it matched exactly the criteria we had previously laid out and required from the literature review. This material had been well tested by literally millions of students over several decades with exceptional results, and so we determined that this was the material we should adapt for New Zealand schools and that is what was done.

In 1996 New Zealand pre-secondary physical science did not have the text resources needed for the new curriculum. This project provided the text resources needed. This enabled primary teachers with virtually no science background in their training to teach the physical science curriculum.

CHAPTER 3 OVERVIEW OF THE CHOICE OF RESEARCH METHOD

This chapter briefly describes research methods used in this project and the rationale behind the choices and why experimental methods were not used. More information is given in the chapters on surveys, questionnaires and action research.

3.1 Enquiry: The Search for Information

In the mid-1990's there were several conflicting descriptions of the same system, primary physical science. There was an ideal and rosy curriculum statement, there were international test scores signaling disaster, there was an ERO report faulting teachers, there were teacher statements faulting administrators, there were administrators faulting the MOE, there were photos faulting classroom architects and planners. The education researcher has to deal with a complex system which is constantly changing and cannot be controlled, altered or entered and where the truth is always 'somewhere in between'. It is a difficult task.

The case history example on the following page illustrates the problem of finding and describing the reality of a situation. Education research often requires a combination of methods - qualitative and quantitative. Information may be correct but misleading. Data need to be triangulated, put together like a connect-the-dot puzzle to get the picture. Information must be fused. An outside researcher may misinterpret published data taken at face value. In education there are layers of meaning and accountability is stratified.

Data need to be understood in context. Terms and language used may have special meaning in specific contexts. What a participant reports doing may not seem to be the same as what appears to the observer as what is actually being done. What is 'for the record' or 'to set the record straight' may contradict what occurs 'off the record'. It is important therefore to take a closer look at the context and at what happens in practice, *in situ* in order to more fully understand any given information. Mistakes based on correct information which is wrongly interpreted can be costly.

Example

Case History

1. On first learning a new baby was coming into the household, Jo wanted to read up on the subject. Reviewing the literature made sense. Jo went to the medical school library and read a book by a doctor which stated,

“New babies sleep twenty hours a day.” (Fact 1)

From that Jo drew the conclusion it would be easy, and that all women before her must have been whingers and complainers. She decided to continue working 8 hours a day while the baby slept. She’d bring a bassinet to work. She wondered why everyone made such a fuss about new babies if all they did was sleep? It sounded so peaceful!

2. Twenty years later Jo picked up a paper and read, “People need different amounts of sleep. Churchill needed only a few hours while babies sleep twenty hours a day.” Jo thought, “Hmmm,...that’s not right.”

“New babies never sleep at all!” (Fact 2)

“...nor should they, so be prepared for the hardest year of your life!” Jo never slept more than 60 consecutive minutes that first year. The baby had a perfect ‘10’ APGAR score- not a single problem. The baby just loved- and needed- to eat every hour. It was the most physically demanding and rewarding year of Jo’s life. That’s just the way it was. And it was five years before Jo returned to work — part-time.

TEST QUESTION

Statement 1 and statement 2 are contradictory but both are true to different experts. Which best describes babies’ sleep?

☐

Fact 1 New babies sleep 20 hours a day.
(statistically accurate literature by experts)

☐

Fact 2 New babies never sleep at all.
(words of a person ‘at the chalk face’)

In the example does a baby sleep twenty hours a day as stated by a physician or not at all as is found by the caregiver? The reality is in between—a combination of the facts from different views. Several methods are used to find the reality. Each of the following bullet points represents a highly developed social research method.

- Literature Search

Literature research is always a starting point and is continuous. Papers are scanned each week, journals read each month, abstracts reviewed constantly, reference books added, new websites scanned. Literature' includes books, articles, microfiches, journals, reports, foreign correspondence, etc. For this project the literature is and has been continuously searched since the inception.

- Observation, ethnography

One could get clues by observing the situation or unobtrusively by, for example, observing lights going on and off or picking up physical clues obtaining photos. These are examples of the unobtrusive research methods of the ethnographer. (Kellehear, 1993; Anderson, 1990). Teachers were asked to take candid photos of their classes using this method of ethnography. The photos were very helpful in clarifying how the subject was taught and what the physical problems were.

- Fieldwork, gaining access

It would be difficult to enter a home for observation just as it is to enter a classroom. It is logistically difficult to enter the scene (Glesne & Peshkin, 1992). In fact, the presence of an outsider could affect or completely alter the pattern being measured (Katzer, 1991). The observer does not want his or her presence to alter what is being observed. (Polgar & Thomas, 1995). The classrooms in this study were not in Christchurch and it would have been impossible to visit any of them. It was not possible to gain access so the presence of the researcher did not affect results.

- Surveys, questionnaires

A questionnaire is be less intrusive. The observer or researcher stays out of the scene. It could be sent by post. But the respondent may be defensive and the answers could be guarded, misleading, evasive, perfunctory, and 'politically

correct', and although not intentionally false, could be either not completely honest or not reflective of the true situation. Both surveys and questionnaires were used in this study. Questionnaires were given both pupils and teachers and surveys were sent to a large number of schools.

- Grounded theory, triangulation

One could ground a theory in recorded data –school or medical charts for example and analyze these retrospectively (Glaser& Strauss, 1967; Strauss & Corbin, 1990). Every attempt was made to triangulate data, but as the main work of this project as approved and funded was in developing classroom resources, the extent of data collected was not as great as if that aspect had been the whole project.

- Action research

In this approach, a person involved in the action keeps a journal of the action and their reflections on it. It is a method of 'on-the-spot' monitoring and recording of a particular behaviour (Cohen & Manion, 1980). In the case of the pretest, the journal would show the baby slept for spans of 20 or 30 minutes between intervals of activity so the total minutes added up to twenty hours out of twenty-four, although it seemed like no one ever slept in the conventional sense at all. If a random sample of caregivers did the same and the information in all journals collated, a pattern of sleep might emerge from which it would be possible to generalize to all babies.

Keeping a journal is time consuming for the teacher but very useful in this research and was one of the methods used.

- Deep notes

Over time there would also be a collection of 'deep' notes on feelings, effects on others, and a general record of the activities and changes (Geertz 1992). This would be informative and accurate and could be used for reflection or other purposes. Some of the teachers kept deep notes in their journals. They added their thoughts and feelings about what was going on and what they were recording as well as adding practical ideas of various things to try.

- Experimental design

A purely experimental design is rarely feasible in a social setting such as a classroom. It is not possible to control enough variables, and not ethical to interfere with normal classroom activity to any extent. Also it is not desirable to control variables. The investigator wants to learn, for example, about the use of books in the natural setting– needs to discover those uncontrollable variables.

- Quasi-experimental design

Even a quasi-experimental design rapidly gets out of hand. In this project books were produced at four grade levels. To test the effect of these experimentally would require classrooms with and without treatment at four grade levels with matched classrooms and matched control classrooms per level. This would require a total of 24 schools as shown in Table 3.1 (Campbell & Cook, 1979).

Assuming no class would drop out (due to school closings, etc.) this design would require a minimum of 24 different schools to start with!

It would be easier to describe the variables which could not be controlled and the limitations of the study than attempt to hold any of them constant (Delamont, 1993). Even if such a large group was feasible, it would not be a controlled study. It would not be practical and would not be valid to use such a design.

- Ethical design

An ethical consideration in the research design (Feyerabend, 1975) was that the pupils should not be subjected to testing. An experimental design that required testing prior to ‘treatment’ as well as at stages during and at various times after, would be intrusive, unethical, and so stressful it could turn both teachers and pupils away from the subject. The method of measurement would interfere with the process being measured if not create opposition to it.

Table 3.1 Impractical Number of Cells for Quasi-experimental Design		
	Treatment	No Treatment
Book 1		
	Class 1-A	Class 1-B
	Class 2-A	Class 2-B
	Class 3-A	Class 3-B
Book 2		
	Class 1-A	Class 1-B
	Class 2-A	Class 2-B
	Class 3-A	Class 3-B
Book 3		
	Class 1-A	Class 1-B
	Class 2-A	Class 2-B
	Class 3-A	Class 3-B
Book 4		
	Class 1-A	Class 1-B
	Class 2-A	Class 2-B
	Class 3-A	Class 3-B

- Non-experimental design

A classroom can be considered a natural organic sociological system with inherent complexities in a constant state of evolution. The introduction of any new material could be considered a small perturbation to the system. What are the effects of the perturbation? Is a new equilibrium achieved? If not, what are the constraints? How can the perturbation be evaluated? In the context of one such effect, can the evaluation process be goal free and open to possibilities and to the discovery of a range of outcomes and unexpected consequences?

The New Zealand educator C.E. Beeby (1975) described evaluation as...

“...the systematic collection and interpretation of evidence leading, as part of the process, to a judgment of value with a view to action”.

According to Anderson,

“...too often educational evaluation is characterized by elaborate methodologies and quasi-experimental methods with mixed or non-significant findings educationally or statistically” (Anderson, 1990).

The word ‘evidence’ in Beeby’s statement includes information gathered by any systematic method—standard tests and measurement, observation, questionnaires and self-report measures (Wolfe, 1979). In the decades since Beebe’s statement the whole field of methods of educational evaluation has burgeoned and in many cases these combine the strengths of both quantitative and qualitative techniques.

- Naturalistic design

A ‘holistic’ approach combines quantitative and qualitative methods. This is also a naturalistic approach, well-suited to a naturalistic system, and is what has therefore been used in this study. Some quantitative information as well as subjective feedback and opinion was obtained from surveys and questionnaires (Polgar, 1995). Action research journals were to give qualitative depth. The teacher became the ‘Practitioner as Collaborative Researcher’ (Cohen & Manion, 1980). Artifacts and materials from the scene, including photographs and student work served to further triangulate the data.

The action-research model was chosen because of its practical, problem-solving nature (Bell, 1987) and because the lab notebook for recording data and observations - quantitative and qualitative data - is also a technique used in laboratory science, the curriculum area under study. Instead of pre- and post-test scores, teacher evaluation and comments described the process. Teachers were the experts *in situ*. They made notes as the action occurred, i.e., as they taught the new curriculum under consideration (Kirk & MacDonald, 2001). The expertise includes knowledge of curriculum prescriptions, practiced skills in understanding and interacting with the primary age groups, ability to make critical, ongoing evaluations of events, and understanding first-hand the effects of any changes or additions, amongst many other things (Shallcrass, 1983).

It is appropriate to use a combination of non-experimental research designs when true experimental designs cannot be used, as in the case of classroom practice research (Anderson, 1990). These methods are well-developed, reliable, and provide information about the system as it exists in its natural state.

In a naturalistic design it is more difficult to evaluate a causal hypothesis than it is in a true experimental design. In this study, for example, the nature of the so-called treatment (teaching material) can be controlled to some extent, but not how, where, when or even to whom it is administered. It is therefore important to 'triangulate' or match and integrate the evidence from a variety of sources to increase the internal and external validity of the findings (Polgar, 1995).

In the analysis portions of this study information was gathered by a combination of methods including closed and open ended questionnaires, closed and open-ended surveys, informal communications, action research journals, photographs, official document statements, historical statements, published statistics, and a naturalistic design. This enhanced the internal reliability of the findings and provided an internal check on meanings of key statistics and words.

However, the project was meant to positively impact the system with materials for classrooms. This model was chosen because this is an area of education critically important to society in which the deliverers of the curriculum are not specialists.

4.1 Pilot Project

A pilot project was conducted in order to test ideas and provide a record of activities for funding bodies. It is described in this chapter.

A write-on workbook for one topic was trialled in a Year 7 and 8 class at a small (220 pupils) primary school over a period of four weeks at one afternoon, 1½ hour lesson per week. It was a class of about 20 pupils, ages 11-12, including one in a wheel chair. A storybook was also made for each pupil to read as an adjunct.

The topic chosen was floating and sinking. It is adaptable (Appleton, 1983; Biddulph 1983, 1985; Symington 1983). It may have originated in the British Isles (Scottish Ed. Dept. 1965). At the New Entrant level it involves a tub, water and objects which can float or sink. Traditionally it is taught by observation because the math quickly becomes complicated. By late primary the pupil has skills to predict if an object will float before putting it in the water. Terms such as 'density' which might be too technical at the New Entrant level would not be at late primary (Biddulph, 1983). It has a fascination, abstract and concrete, descriptive, qualitative and quantitative. It is universal, gender-neutral, requires no specific prior knowledge, relies upon experience, lends itself to a number of teaching strategies, and basically is fun. It requires no exotic materials or chemicals and can be run as a practical session. It can be done individually or in groups. Parts can be done at desks, other parts in lab areas. It provides opportunities for interactive learning.

Physical science topics which it touches on include miscibility of liquids, partial pressure, ideal gas behaviour, solid, solution, solubility, weight, mass, volume, states of matter, relative density, molecular structure, particulate nature of matter, ionic solution and others. Measurement skills and instrumental, analytical, problem-solving and other practical skills come into the topic as well.

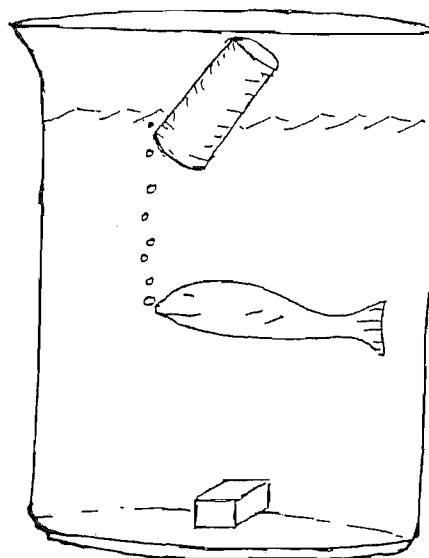
A write-on workbook and accompanying storybooks were developed. The workbook was written to incorporate the criteria determined from the literature search.

1. Use of numbers to describe concepts like density, relative density, sinking, floating, submerging, percent buoyancy, buoyancy, force, specific gravity.
2. Measurement skills: volume, mass, weight, linear rule, time, comparative measurement, relative error, etc.
3. Use of special language: density, molecules, formulae, H_2O , NaCl , elements, symbols: m, V, P, gm, ml, l, greater than >, less than <.
4. Paper chemistry, paper physics: diagram the events, diagram the density of salt water/ plain water, tabulate data, draw relative densities, etc.
5. Practice in applied math: addition, subtraction, multiplication and division, averages etc.
6. Building on prior knowledge and skills, reinforcing the known, introducing counter-intuitive concepts.

Each pupil was provided a write-on workbook. The classroom was that of a typical New Zealand primary school—each pupil had a separate slant-top wooden desk and the floor was carpeted. There was no bench to work. The desks had to be pushed aside and the work done on the floor. The teacher's desk was full of books and papers so a student desk was used for demonstrations. There was a small sink in the cloak room with the art supplies. There was no equipment. In addition to the books, it was necessary to bring in scales sensitive to 0.1 gram, measuring cups, cylinders, flasks, eggs, calculators, salt, towels, basin, bungs, corks, stirrers, etc. There was open discussion at all times.

At the start of the workbook was a 'prior knowledge'- type set of questions: Why does an object sink? Would it float if the water was deeper? If the object were longer? etc. The 'less than', <, 'greater than', >, and 'equal to', =, signs were reviewed. Some students understood the concept 'density' but could not see how to find it for water, i.e., because it had no 'thickness'. After learning that the density of pure water is 1 (gram/ml), reviewing the meaning and use of the words density, volume, cubic centimetre, millilitre, 5 drops = 1 ml, and '1 gram per ml' the students completed a table by writing '<1', '=1', or '>1' to describe the relative density of

objects which floated, stayed submerged or sank. Students were asked about their knowledge of writing chemical formulas, and many knew that water is sometimes called H_2O and salt NaCl . A conceptual sheet of paper with water molecules written on it was then made more dense by the students writing in salt molecules.



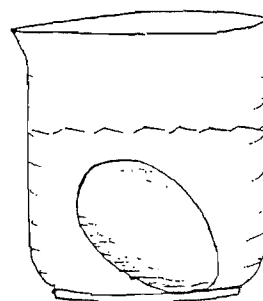
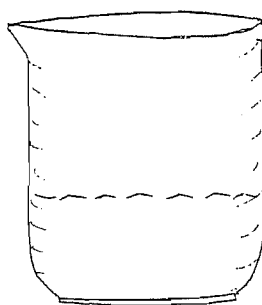
Discussion allowed students to give their ideas such as that in salty water one needed more lead weights to scuba dive, or that the Dead Sea was very salty. Students were shown the structure of ice and talked about why ice floats.

The first experiment was to weigh and measure volume by displacement of bungs and corks, calculate their densities, predict which would sink or float and test out the prediction. Considering the difficulty of this work, technically and mathematically, the students did well. If the density was found to be greater than 1, they predicted the object would sink and it did.

Next, the students were given eggs. As for the bungs and corks, the odd shape meant the volume must be measured by displacement. The pupils were excited about getting the eggs and had theories about which eggs would sink or float. Some felt that Free Range Eggs would sink. Some of the students carefully did all the calculations. Others

just dropped them in the water to see if they sank or floated.

For this class demonstration it was important to make sure all the eggs would sink.

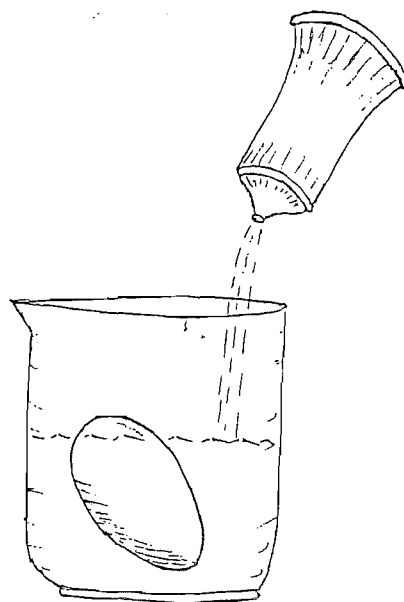


The students then could add salt until the egg re-floated, understanding that they were making the density of the water greater than that of the egg. Some students re-weighed and measured the salt water to find its density and show it had increased.

The project overall showed the utility of the workbook and guided-discovery format and the difficulties of teaching quantitative lab activities with no apparatus and insufficient space and facilities.

In the last session the pupils moved the desks in to form one large table and worked together to write and illustrate stories about the topic. Further information was discussed about why boats float. The main story the class worked on was called "But Willy, Will It Float?" All the students contributed ideas and images. This was a story about a

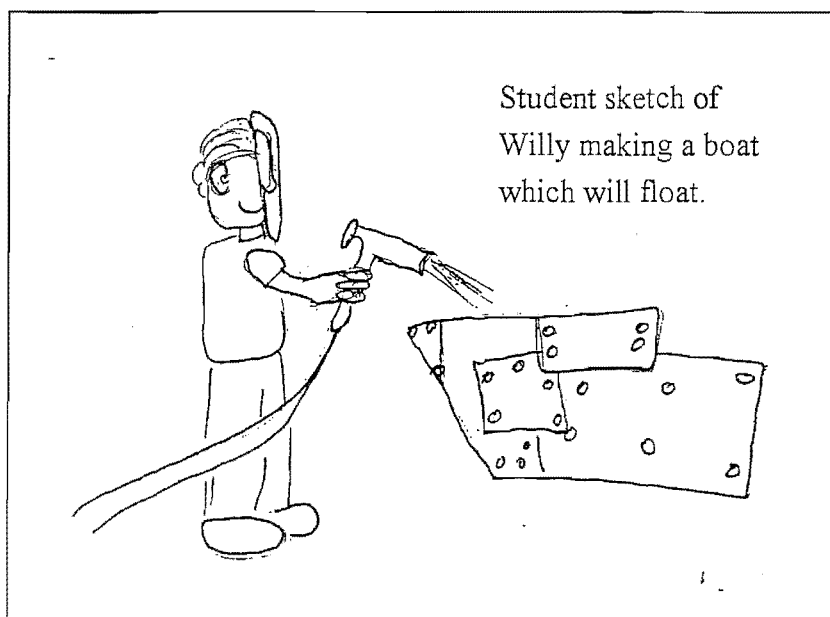
youngster who builds several boats which sink for various reasons, then reads up on density, measures out a boat, calculates its density, builds it, names it "Weigh Out", and sails off.



The regular teacher had trained in the 1950's and science was not required at the time of her credential. During the sessions of this unit she was not in the classroom. This unit along with overhead transparencies, images of Archimedes, pages from the work booklet and so forth were later used as a training unit for primary teachers and contributed to a teaching video as well.

Prior to this unit the students had done science one hour a week on Wednesday afternoons and it mostly meant reading picture books about outer space. This was in the early days of the new curriculum. The students were favorable toward the challenge of this unit, and looked forward to going to secondary school for more.

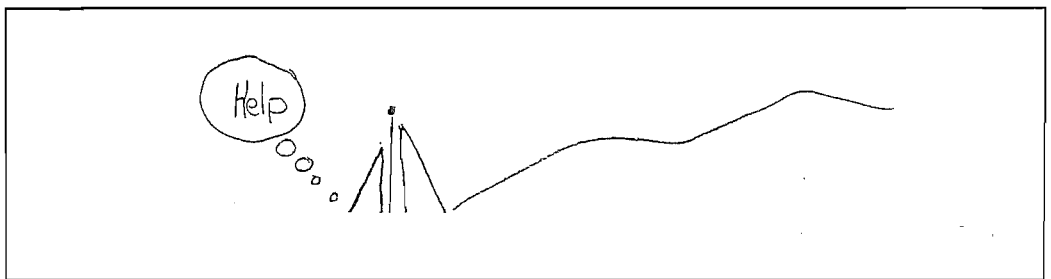
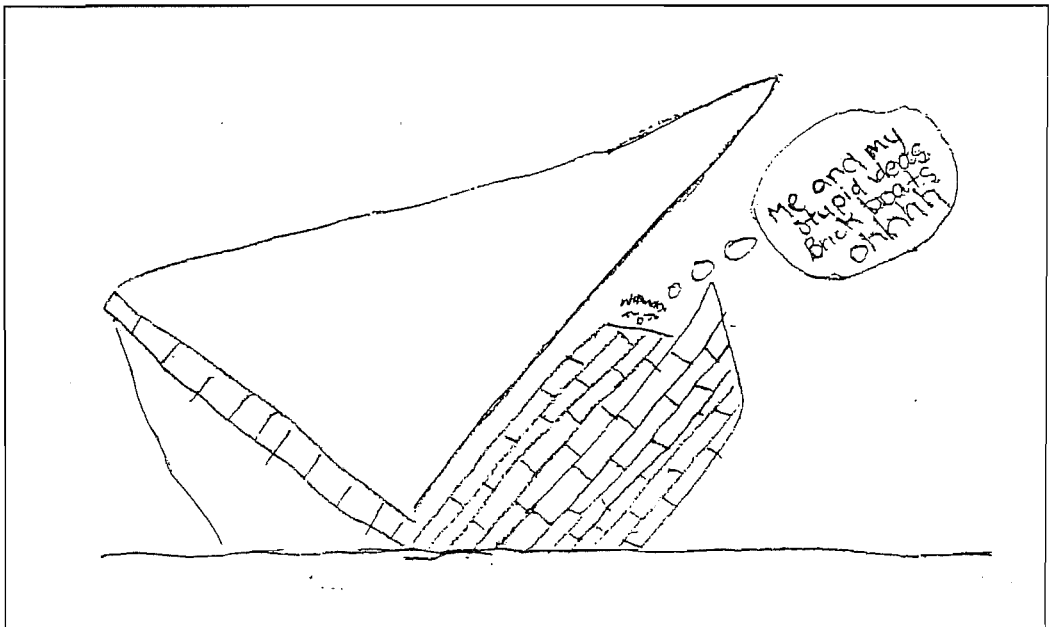
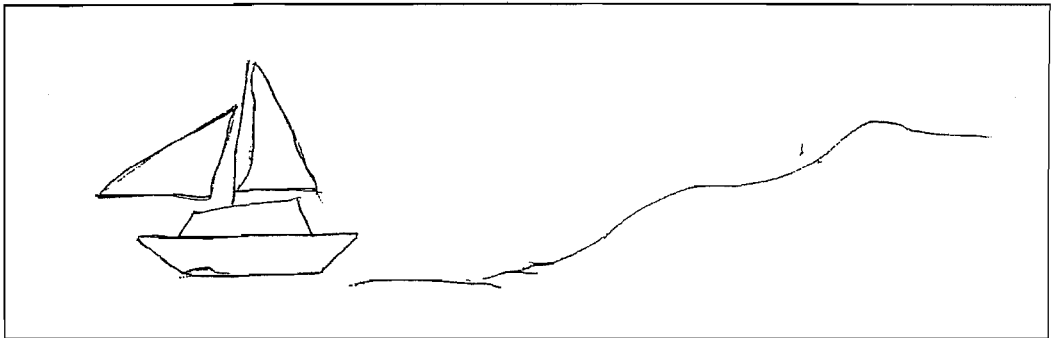
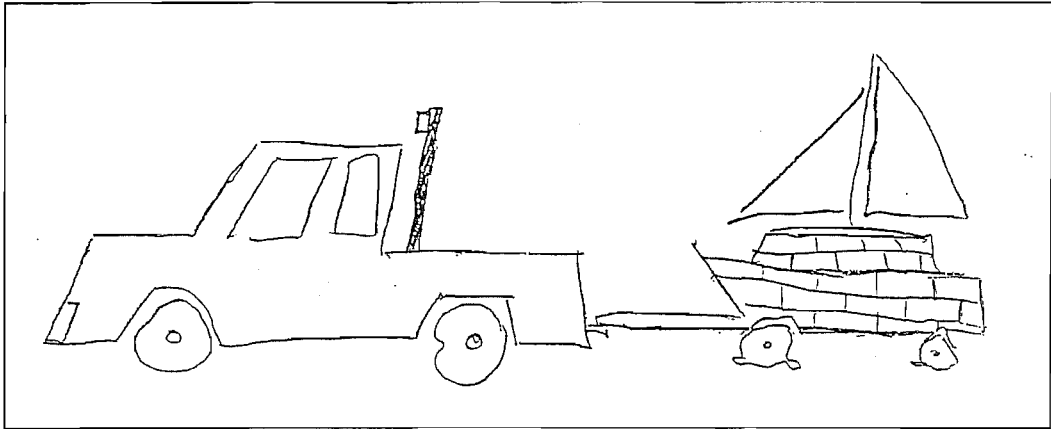
One student conceived of Willy as a panel beater, as shown below.



After the unit was complete, the pupils were given review questions. They remembered many items and incorporated new vocabulary words such as H_2O and $NaCl$ in their responses. The unit had new and unfamiliar language, math applications, laboratory activities, equipment (with new names), and people, all introduced in very limited time. In the last three sessions a fast-food chain representative was also coming into the classroom at the same time to get the students' opinions of different monsters for their new ad campaign. This was exciting for the pupils and caused them to miss some of the activities in the sequence. Some noted this on their review sheets.

The pilot project provided a good background to obtain funding for the main study.

Student sketches



A book survey was used to determine what resources were available in 1998 for teaching The Material and Physical World prescriptions. It showed a dearth of material. One school listed only a book by Dr. Seuss. The respondents unanimously cried for teaching material and supported this project in making it.

5.1 Methods-Book Survey

The book survey went to a random selection of primary and intermediate schools in the Canterbury Region. Educational institutions are grouped into 15 geographical regions corresponding roughly to the 15 provinces. Canterbury is the region surrounding Christchurch.

The information was sought from pre-secondary schools in the Canterbury Region. There was a total of about 250 of such schools. The survey was used only to collect information about the current state of that population. The information obtained provided an indicator of the situation only.

The sample comprised schools which had a Christchurch Yellow Pages listing and were also normal full primary (Y 1-8), intermediate (Y 7-8), or contributing (Y 1-6) schools. The survey was sent to 70 schools. The sample of schools to which the survey was sent reflected the decile characteristics of the population.

The survey was constructed to be as appropriate as possible for the respondents; it was short and simple, informal, did not request personal information, and was administered by mail so could be answered at any time. It was intentionally similar in form to a familiar 'Read Alouds Survey for Years 3-8' sent periodically to schools from the Children's Literature Association. No information about the school other than the name was requested. Most general information about public schools is available on the MOE website including size, administrative type, urban or rural location, gender mix, and decile.

Resources are no longer supplied automatically to schools as they were under the old Department of Education. Since the advent of bulk funding, spending is at the discretion of each individual school board. Since expenditure for resources is tied to the economic factors, the school decile was noted. Decile assignments range from 1 to 10. It indicates the extent to which the school draws its students from low socio-economic communities. A decile 10 school is a school in the 10% of all public schools in the nation which draws the lowest proportion of students from low socio-economic communities. The socio-economic indicator used to calculate decile includes factors such as household income, adult occupation, household crowding, adult educational attainment, and levels and type of income support. Decile information is available to the public.

Table 5.1 shows the percent of the survey population, sample, and respondents in each of the ten decile categories.

Table 5.1 Percent of Population, Sample, and Respondents in each Decile (*Private Academic by Number)			
Decile	Population (%) Canterbury Schools	Sample (%) (Yellow pgs listing)	Respondents (%)
1	1	3	0
2	6	6	0
3	9	8	7
4	9	10	0
5	6	9	0
6	10	4	7
7	14	8	7
8	15	15	13
9	13	11	7
10	17	26	59
Number	266 schools	81 schools	17 schools
*Private	-	1 school	1 school

For convenience, comparison with other data, and so that the value in at least 80% of the cells is greater than 5, categories 1-5 and 6-10 were combined giving two groups: i) schools of decile 1-5 and ii) schools of decile 6-10 (Burns 2000). The grouped data are displayed in Table 5.2.

Table 5.2 Percent of Population, Sample, and Respondents in High and Low Decile Groups			
Decile	Population (%) Canterbury Schools	Sample (%) (Yellow pgs listing)	Respondents (%)
1-5 (Lower)	31	36	7
6-10 (Higher)	69	64	93

The sample matches the population. The respondents were higher decile since Canterbury has a relatively high number of high decile schools.

Table 5.2 shows the population and sample are matched fairly well in terms of the two decile groups; decile 6-10 schools make up most (69%) of the population and most (64%) of the sample. The decile 6-10 group made up 93% of the respondents excluding the Private Academic school, normally also a high decile school.

The decile of the respondents tended to be high. Since these high decile schools reported a lack of resources it might be inferred that lower decile schools would have an even greater lack of resources or at least that they also lacked resources.

This survey generated not only data but many letters of support for the project, i.e., for making books for schools.

5.2 Results-Book Survey

The book survey conducted in 1997/8 asked respondents to list any material related to the physical sciences, whether it was used for teaching purposes in the classroom or not, including any texts, write-on workbooks, picture stories, videos or any other material available for use at school or in the school library or which could be taken home. Respondents were specifically asked to exclude material relating to other sciences such as biology, geology, botany, zoology, computer science, geography, and so forth. They were specifically asked to name any material which they would use either as a primary or secondary resource for the new Physical and Material World parts of the curriculum. Respondents were also asked to comment on whether or not there was a need for more, better, or other physical science material, and whether or not local content was important.

All the respondents, from those with the shortest list to those with the longest, affirmed that they would like more material for teaching physical science. The following comment from a prominent private academic Christchurch school is typical:

“...Of all the divisions in the new science curriculum, the Material World is most poorly served, followed by the Physical World.”

In addition, other respondents wrote their lists and comments.

- All respondents wanted (more) material in physical science.
- All respondents wanted local content in the material.
- No two schools used the same material.
- There was a range from 1 to 25 items reported.
- Some schools did not distinguish physical science from other sciences, either because the difference was not clear or because the same book covered several areas. Some included fiction books on their list.

The lists are in Table 5.3, with title, publisher or author as given by respondent.

Table 5.3 Resources listed in 1997 for teaching physical science.

<u>School</u>	<u>Title</u>	<u>Author, Publisher, or Source (if given)</u>
I	Moving	Brenda Walpole
	Floating & Sinking	Barbara Taylor
	Fun with Science	Robin Kerrod
	The Usborne Book on Science Fun	Johnson
	Sound Waves to Music	Neil Ardley
	Simple Chemistry	Steve Parker
	Super Science Book of Materials	Chambers & Peaco
II	Sunshine Science Series	
	Literacy Links Series	
	Usborne Series	
III	Kingfisher Fun with Science Series	
	Science Workshop Series	Watts
	Flying Start Science	
IV	Science Experiments	Jane Bingham
	Chemistry Experiments	Mary Johnson, Pocket Scientist
	Simple Chemistry	John Paull, Lady Bird Science
	Simple Science	Angela Wilkes
	How things Work	Martyn Bramwell
	The Great Zopper Toothpaste Treasure	Jennifer Bach
	Thematic Problem Solving Using Technology and Enterprise	Margaret Paterson
	Science Construction Projects	Ormiston H. Walker
V	Fun With Science - Simple Chemistry	Steve Parker
VI	Mr. Archimedes' Bath	Pamela Allen
	Up Went Edmond	Diana Noonan
	How do you Lift a Lion	R. E. Wells
	Fun With Science	Kingfisher
	Fun With Simple Science	Kingfisher
	Science Starters	Franklin Watts
	Science Workshop	Watts Books
	Introduction to Physics	Usborne
	Introduction to Chemistry	Usborne
	The Ogs Learn to Float	Usborne
	The Ogs Discover Fire	Usborne
	The Ogs Learn to Fly	Usborne
	Who Sank the Boat	Pamela Allen

VII	Colour and Light	Barbara Taylor
	The Usborne Book of How Things Work	Marilyn Bromwell
	Colours	Constance Milburn
	Colour	Terry Jennings
	Projects	Ron Taylor
	Learn Shapes and Colours with the Much Bunch	
	Light and Colour	Terry Jennings
	How the Birds got their Colours	Panda Lotts
	Gardener George Goes to Town	Susan Moody
	Air, Light and Water	Jackie Gaff
	Colours	Sally Morgan
	Colours in Science	Sally Morgan
	Kingfisher Child's World Encyclopedia, Vol. 9	Jim Miles
	How Things Work	Robin Kerrod
	Energy	Terry Jennings
	Energy and Light	Peter Lafferty
	Bouncing and Rolling	Terry Jennings
	Energy and Industry	Sarah Millar
	The World of the Microscope	Chris Glade
	Structures for Living	Carol Jones
	Building Things	David Evans
	Clocks, Scales and Measurements	Pam Robson
	The Usborne Book of Scientists from Archimedes to Einstein	Struan Reid
	Dr. Jekyll and Mr. Hyde	John Grant
	Air	Terry Jennings
VIII	Fun With Science	Kingfisher
	Simple Chemistry	Kingfisher
	Moving	Kingfisher
	Electricity & Magnets	Kingfisher
	Informazing Resource Book	
	LHS GEMS	Lawrence Hall of Science
	Crime Lab Chemistry	Mystery Festival
IX	Supplements which vary	National Library Service
	Kitchen Chemistry	(Otago)
	Forces & Movement	Terry Jennings
	Light, Colour & Lenses	Pam Ribson
	Elements, Mixtures & Reactions	Mick Seller
X	Fun With Science Series	Kingfisher
	Science Workshop Series	Watts
	Flying Start Science	
XI	Flight	National Library Service (NLS)
	Plant Science	NLS
	Space	NLS
	Antarctica	NLS

XII	The Way Things Work	David Macaulay
XIII	The Oobleck	Dr. Seuss
XIV	Chemistry Simple Chemistry	Dr. Ann Newman Ardley
XV	A World of Matter	Alive Science
XVI	Kitchen Chemistry, Step by Step 100 Mini Scientific Experiments Folens Science Materials Copymaster Visual Factfinder Science & Technology	John Bath & Sally Mayberry Ormiston H. Walker Bob Hayward, Michael Pearce Kingfisher
XVII	Science Starters Series How Things Work: Lifting by Levers Learn About-Series Fun With Science Young Discoverers Series Young Scientist Series Designs in Science Series Science in Our World Series Young Scientist Investigates Series Sunshine Books Science Series Rigby Realization Technology Series	Watts Books A. Dunn MacMillan Australia Kingfisher Kingfisher Usborne Evans Bros Macmillan Oxford Heinemann Education Rigby Heinemann

This lists show schools had a variety of background material related to physical science, but most are books that would be found in the school library and not class texts. They include picture books, story books, activity books, pamphlets, copymasters, book series, encyclopedias, and materials (including videos) from the National Library Service (NLS), amongst others.

No school noted any government publications, pamphlets or internet material. No school listed a textbook per se. Most of these resources met the 'good book' criteria i.e., modern, colourful, age-specific, and so forth, none of them was written for the new NZ curriculum, and none was designed to be used as year-long course material with teacher guides for a typical New Zealand class of 30 pupils. Most were published overseas and did not contain local references.

Teachers at that time cobbled together activities, but a scattershot effect could result from photocopying single pages from different books to piece together a teaching unit. Although the syllabus might be covered, a transferring pupil or one who had been absent might experience difficulty collecting the missed pages or building on the prior experience.

It is interesting to compare the books of 1997/8 in this survey with those of 1897/8 (Austin, 2002). In the earlier days the books usually were written by a single author such as a university-level professor (Austin, 2001). Modern books are often compilations of material which has been tested over time and put together by a publisher or gathered under the name of one or two authors who may have compiled the material, or re-written material or may simply be named for promotional reasons. Some, but a minority are authors in the traditional sense of the word.

From the results of this survey it was clear that a possible reason for under teaching physical science in 1997/8 was a dearth of appropriate, classroom oriented teaching material designed specifically for the new curriculum.

It was apparent that many classrooms lacked practical equipment, so a resources survey was sent nationwide to determine the extent of the problem. This chapter reports the statements of the respondents and shows that while over half the classrooms are under-resourced there are other systemic problems such as poor classroom design which impede the teaching of physical science.

6.1 Methods—Resources Survey

The book survey had shown there were few print resources for physical science lessons in the late 1990's. While four years of workbooks were produced in this project, text resources concurrently appeared from other sources and the internet. Even with plentiful teaching material, it was noted in follow-up questionnaires that respondents still did not positively state they were teaching the new curriculum. Since physical science is traditionally a lab or activity-based subject, one problem was a lack of equipment.

In the early book trials it had been necessary to supply not only the books, but all the equipment for the activities as well. The cost for one kit for one class of 30 pupils sharing in threes was over \$500 by the author. The supplies sent to the participating class (North Island) for use with Book 2 are listed in Table 6.1. Even with the basic equipment the teacher still had to come up with many items and needed a suitable classroom with at least one sink and some bench space. teaching.

The resources survey was generated to find out more about these problems. Aside from lack of equipment, teachers also mentioned being hindered by carpeted floors or desks which were not meant for group work and other built-in physical barriers. The resources survey was sent to get more information about these problems and included some questions about teacher background and attitudes as well. Teacher comments and suggestions were encouraged.

Table 6.1

Supplies Sent : Workbook 2

(page 1)

No. of Students in Class: _____ No. of Students per Group: _____ No. of Groups: _____

No. sent	r/s/o	Chapter 1 2 3			Activity (page)	Item	Vendor	Catalogue Number	Price	Total
32	o			x	(extra)	alligator clips	Crescendo	FTH 007		
	r			x	A5,P12	aluminium foil				
	r	x			E, A3	baking soda, fresh				
	o	x			A2	balance, double pan				
1	r		x		A8	ball and ring apparatus	Delta	43BR20		
10	r	x			A2	balloons, large party				
	r		x		A2,P11	basins/large mixing bowls				
16	r			x	(many)	battery holders for 2 'D' cells, with alligator clips*	Crescendo FTH 2190 *See Instructions in Tech Gde for pulling alligator clips on the battery holders			
24	r			x	(many)	batteries, 'D' cells				
3	s				(extra)	beaker (600 ml)	Crescendo	BKG 1755		
	s	x			A1	beans (dried kidney)				
4	r	x	x		TT, A7	blu-tack, plasticine	Mitre 10			
	r		x		A10	bottles, plastic milk (15)				
	s		x		A1	bottle cap				
	r	x			a few	bottles, wide-mouth				
						bulb—see lamp				
	s	x			A9	candles, birthday				
	s	x			option	candles, tea warmer				
10	s	x			A7,8,9	candles, white utility				
50g	r	x			For Fun	Ca(OH) ₂ (calcium hydroxide "hydrated lime")	Crescendo	CHE 2097		
35	r			x	A 6,P12	card (10 x 15 cm pieces)				
2.5						capillary tubing (for 100 ml flask) 1.5mm bore, 40 cm	Crescendo	UNL 3101		
	o		x		Intro	ceramic tile				
	r	x			a few	chalk				
	r	x			A8	clock, stopclock				
yes	s			x	A5	cloth (ribbon)				
	s		x		A5	coathangers (metal)				
	r		x		A7	cola cans (16)				
						conical flask-see flask				
	r	x			A5	cornflour				
10	r			x	A5,P12	copper strips (2 x 5cm)	see Wkbk 1			
5	s	x			A 2	cork, large				
18						cups				

Supplies Sent : Workbook 2

(page 2)

No. of Students in Class: _____ No. of Students per Group: _____ No. of Groups: _____

No. sent	r/s/o	Chapter 1 2 3			Activity	Item	Vendor	Catalogue Number	Price	Total
12	r	x			A1	envelopes (used)				
	r			x	a few	erasers (flat, rubber)				
	s	x			A 1	feathers				
7	s		x		A 9	flask (100 ml w stopper & tube)	Crescendo	GLA 0776		
	r	x	x		a few	food colouring				
	s		x		a few	glass stirring rod (or any small spoon)	Crescendo	UNL 1392		
2m	o		x		E 3	hose to fit glass tube				
5	r			x	a few	knife switch	Crescendo	EDU 0199		
1						ladle				
26	r			x	a few	lamp (bulb), 2.5V, 0.3A	Crescendo	WSI 0544		
26	r			x	a few	lamp (bulb) holder	Crescendo	CRO 0205		
2pk	s			x	a few	leads w alligator clips	Crescendo	EDU 2482		
1pk	r	x	x	x	a few	magnifying glasses (10)	Crescendo	UNL 0251		
	s	x			intro	marbles				
	r	x	x		a few	matches				
10+	r	x		x	a few	nails, 10cm, 7cm steel				
	s	x			A 2	needle				
	o			x	demo	OHT Transparencies				
	r	x	x	x	a few	paper (tissue, typing, etc.)				
pkt	r			x	a few	paper clips (metal)				
	s	x		x	a few	pegs, clothes (wooden)				
	r	x	x	x	a few	pen (marker)				
ctn	r			x	A 5	pencil lead (2B) (carbon)				
	r	x	x	x	a few	pencil with eraser				
	r	x			A 6	pestle (wood stick)				
1						Phillips screwdriver				
10	r	x			TT	ping pong balls				
	s	x	x	x	a few	pins				
	s	x		x	a few	plastic bags				
18	r	x	x	x	a few	plastic water cups				
4pk	r	x			a few	plasticine				
5	o			x	demo	plug, transparent demo				

Supplies Sent : Workbook 2 (page 3)

No. of Students in Class: _____ No. of Students per Group: _____ No. of Groups: _____

No. sent	r/s/o	Chapter 1 2 3			Activity	Item	Vendor	Catalogue Number	Price	Total
						retort stand with clamp	see Wbk 1			
						ruler, 1 metre, wooden				
						rubber stopper, 27 mm for 100 ml flask	Crescendo	BRE 1419		
						rulers, plastic, metal, wood				
	r	x			A 5	salt				
2	r	x			a few	sand tray (cat litter tray)	Bin Inn			
	s	x			Intro 1	school bags				
	r	x			A 1	scissors				
	o			x	a few	screwdriver (Phillips)				
1	r	x	x		a few	spirit burner (uses meths)	Crescendo	CRO 0258		
	r	x			A 1	stapler				
						stopper, 1-hole for conical flask	Crescendo	BRE 1419		
	s	x			A 1	straws, stiff				
	r		2		a few	straws, bent				
10	r	x			A 4	syringe, plastic 10 or 20 ml	any pharmacy or veterinary			
	r	x			DYK	sugar				
	r	x			A 5	tablespoon (metal)				
pkt	r	x	x	x	a few	tape (masking, cello, etc)				
	r	x			A 5	tapioca flour or cornflour				
10	r		x		a few	thermometer (alcohol)	Crescendo	CRO 3043		
	r	x		x	a few	thumbtack (drawing pins)				
	r	x			a few	thread, string				
	r	x	x		a few	tongs (for crucible)	Crescendo	CRO 0097		
	r			x	a few	torches with batteries				
	o	x	x	x	All	teaching video				
	r	x			A 5	vegetable oil				
	r	x	x		a few	vinegar, white				
	o	x			Intro	weight, 200gm (or rock)				
10	r			x	a few	wire, multistrand insulated	Radcliffe Electrical Chch			
1	r			x	extra	wire stripper/crimper	"			

r = required, o = optional, s = can be substituted or improvised.

Resources Survey

For the purposes of the survey ‘physical science’ was defined as that in ‘The Material World’ and ‘The Physical World’, 2 and 3 of the four contextual strands:

1. Making Sense of the Living World
2. Making Sense of the Material World
3. Making Sense of the Physical World
4. Making Sense of Planet Earth and Beyond

The survey was used to learn what resources schools had and what they needed. It also had attitude questions about the subject and asked some information about the background of the respondent. The survey had 85 questions in six sections.

1. Section 1: respondent’s background
2. Section 2: effectiveness of current training and resources
3. Section 3: student and teacher attitudes toward the subject
4. Section 4: school demographics
5. Section 5: teaching practices
6. Section 6: open-ended so that respondents could...
 - list all types of resources to which they had access.
 - list any resources they needed.
 - suggest ideal or ‘dream’ resources.
 - make any other comments or statements.

The survey was confined to one double sided white A4 sheet. They were sent as a one-time ‘onsert’ with the *Education Gazette* (www.edgazette.govt.nz) a bi weekly publication sent to all schools. From one to ten gazettes, depending on school size, are bundled by the printer. The bundle goes to all schools in general categories. Extra notices, information and advertisements can be inserted in each gazette (insert) or piled on top of the stack (onsert) before bundling. The latter is the cheaper option. The cost of sending the survey this way was one fifth that of posting it and time was saved from having to find and type address labels. There is no control over how the onserts are handled once the bundle is received at the school. They may be read, passed around or discarded.

Five hundred surveys were sent to the printing plant in Petone. This represents 20% of the pre-secondary school population of about 2,500. The instruction was to include only one survey per bundle, i.e., one survey sent to each school irregardless of school size. Because of this method of distribution, probably only 400 surveys were received at appropriate (yr 5, 6, 7, or 8) schools. Eighty five surveys were returned. This represented about 25% of the estimated number of surveys.

The survey asked questions about compliance and about teaching practices so a return address was voluntary. A book draw was devised to encourage responses and a non-detached return address was needed to go in to win. All provinces and the Chathams were sent forms. Questionnaires were sent in Term 3. No return date was requested out of respect for the busy schedules of the respondents.

Responses to the closed questions were analyzed by computer using Excel for frequencies. Open question responses were analyzed by categorizing the responses into broad groupings and tallying them. Respondents' actual written comments were reported in italics.

6.2 Results—Resources Survey

Eighty five samples were returned. This was a little less than 30% of those which reached the intended recipients. About 50% of the respondents chose to remain anonymous. The other half supplied their name and went into the book draw. Three schools won a class set (50 books) of Student Workbook 1. All schools which went into the draw were thanked and sent a sample workbook and notification of the city of the three winners. The postmark of each response was recorded and reflected a wide geographic distribution. Many respondents did not answer all questions. Only a small number answered all of the same questions. It was therefore possible to record, tally and report the results, but statistical inference was limited.

Most were received within three weeks of the mail out. Some schools sent a computer printout of all science supplies for all subjects. Others made it clear they had no supplies and no time to answer. Very few schools reported having sufficient resources, and all had good suggestions.

Section 1: Background Information

A group with many years of experience-

43% of the respondents had been teaching 21 to 30 years.

Most were female- 75% were female.

Half preferred teaching science-

50% listed science as one of their favorite subjects to teach.

Science background-

95% had completed some secondary science, if only to 4th Form or School Cert. Levels.

University science-

5% had completed at least one tertiary science paper.

Section 2: Training

Is more in-service training needed?

A slight majority, 60%, felt that in-service support would be useful.

Are teaching resources sufficient?

Only 29% felt teaching resources available were sufficient.

Is pre-service training effective?

Only 10% felt that College of Education science courses gave sufficient training.

Section 3: Attitudes

For the twenty five attitude questions, only one or two respondents were not positive toward teaching these subjects. Since the section was brief, a non-answer did not indicate non-agreement. Responses only confirmed statements selected.

Nearly all did not consider the topic boring, despite boring examples given.

95% emphatically did not feel the subject was boring.

Virtually all respondents completing this section noted pupil enthusiasm.

80% reported that the students were enthusiastic about the activities.

Only a minority indicated they had sufficient equipment.

25% indicated they had sufficient science equipment.

Section 4: School Demographics

50% of the schools were full primary/intermed (years 0-8).

48% were contributing primary (years 0-6).

40% had over 300 students at their school.

23% of the schools were in the lower three deciles (1, 2 or 3)

39% were in the upper three (8, 9 or 10) decile.

Respondents were evenly distributed geographically.

Section 5: Teaching Practice

Average pupil age: 10.

35% (the largest sub-group) had median class age 10 year old

Most had large classes.

Class size for 65% of the respondents was between 21 and 30 pupils.

Most taught over a two-year cycle.

81% had combined classes and taught over a two-year cycle.

Most did not have sufficient equipment.

70% said there were not enough practical resources to teach these subjects.

Section 6: Resources

39 % of the respondents said they had access to some books

16% mentioned using the National Library Service

17% used the Internet.

17% said they had some science equipment.

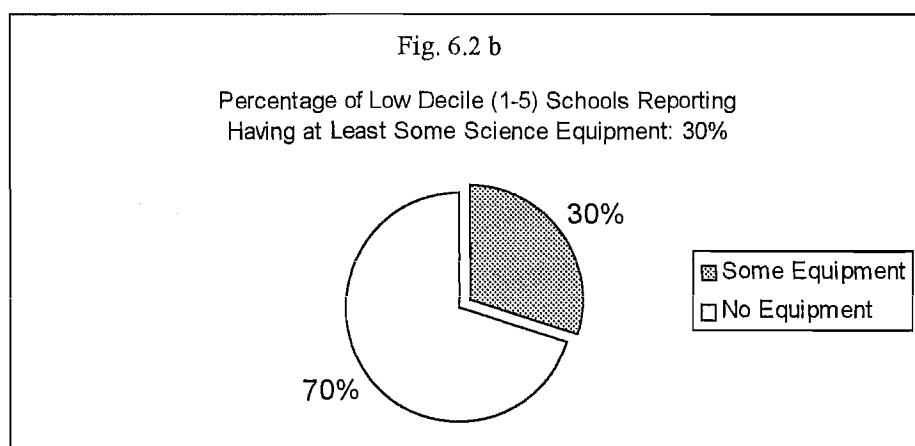
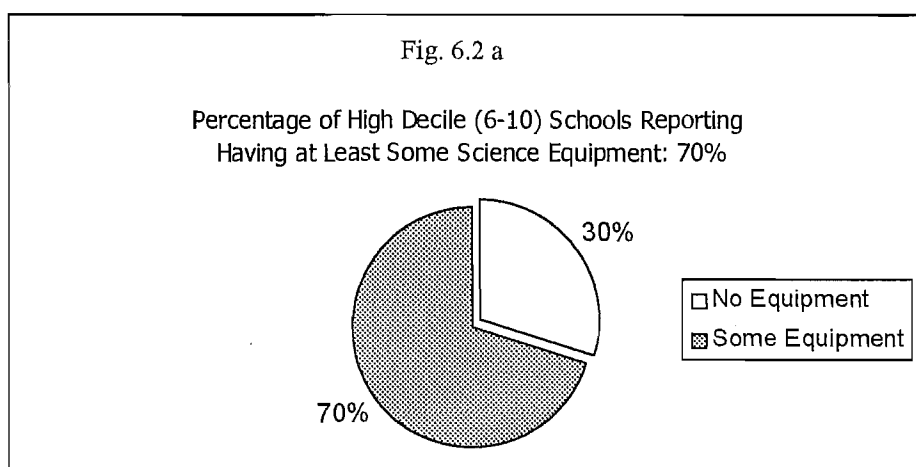
Section 6: Open-ended questions about resources

The last page of the survey consisted of open-ended questions. The respondents were free to answer as they chose. Comments are shown in italics.

What would you ideally like to have? *A well-resourced school.*

Respondents did not answer all the questions, but virtually all respondents gave information about their school, including decile, so decile could be matched with equipment needs. The decile assigned to a school is a number which corresponds roughly to the socio-economic level of the homes in close proximity to it, going from a high of 10 to a low of 1.

Fig. 6.2 Reported Resources by School Decile



Most schools reported having at least some equipment and some text resources for some activities. There was a spread between 'haves' and 'have-nots' reflected to some extent by school decile. Fig. 6.2 illustrates the following:

- (a) 70% of the higher (6-10) decile schools reported having at least some equipment.
- (b) while only 30% of the lower (1-5) decile schools did so.

Although the age of the school was not asked, some schools reported being 'older' or 'newer', and some 'older' schools reported the advantage of having been able to accumulate supplies over the years, and some 'older' teachers had held on to the old Department of Education resource kits which they valued highly.

...the old Dept. of Ed. Science Resource Units are still a valuable resource.

We find equipment and go from there, limited by the equipment available as we are a 'newish' school still building up resources.

The school is 'broke', severely under-resourced, missing most resources provided free from the govt. So we don't have much in the line of resources.

Most respondents saw 'resources' as information sources from which they would gather bits of information to put together to make their own resource—a lesson or unit plan based on the equipment which they had or could...

Share—after beg, borrow (from T. Coll., neighboring schools, Intermediate), stealing or buying ourselves.

I collect materials and resources from a variety of sources and extract the information / activities that support the learning outcomes.

As units are planned, material is gathered.

I don't know until the unit is decided- then I seek material and resources.

I use as much as I can search out. Most (books) have a little bit that's useful.

Time is paramount when organizing for a unit.

(I) Teach (science) more like a social studies lesson—no equipment.

Science goes into the 'too hard' basket—no equipment.

The cost in terms of teacher's time in preparing units in this way was often noted.

Teachers have not got the time to plan everything right from scratch.

The cost & time of gathering equipment limits the breadth of investigations.

Schools ranged in size from Yr 0-8 schools with over 500 students to sole charge schools of about 10 pupils ranging from 5 to 12 years old. In both cases it was common to group children into wide age ranges of two to three year age spans for teaching science. The wide age (and thus ability) range in some classes was noted:

Resources most useful to me would be anything which helped teaching in a multi-level classroom.

L2-L4 topics are very different as are the skills of the children at these different levels.

Any help would be extremely useful.

Children were grouped in wide age and ability ranges on a social (not academic) basis even when the school was large enough to have separate same-age classes.

We are an open plan block so approximately 100 children (ages 8-11) are doing the same science unit at the same time often on a rotational basis around the four teachers who cover a different aspect or experiment each.

We try to be as 'hands on' as possible with the resources available, but....

And some suggestions from the same school with 100 children in one open plan,

It is not cost effective to buy large numbers of equipment to be used a few weeks each year....

My ideal solution would be sets of equipment on loan from a central resource bank.

This suggestion was made by many schools. Some Colleges of Education have increased support of this kind in the intervening time since this survey was sent.

Different spoken languages created a problem in some schools.

Teaching science when a third of the class does not speak English is hopeless.

The formal time allocated for teaching these units ranged from 2 hours once every two years to several weeks per term with lessons subject to resources on hand. However, the time allocation was difficult to accurately quantify since for most...

Units are integrated as much as possible with language, math and technology in particular.

What are the resources?

We don't really have a lot of resources for this area at all.

We have more for The Living World & Planet Earth & Beyond.

Many schools listed the free MOE "Making / Making More / Sense of..." resource booklets with comments ranging from ...

...next to useless! to ...these are great!

Books and series listed were similar to the ones which appeared on the book survey: *Macmillan Science, Curriculum Concepts, Shortland Science Alive, Kingfisher, Usborne, Heinemann, Ginn, Kingfisher, Sunshine Science, Exploring Science*

Also mentioned was the *National Library Service, 'fifth form' books, personal book collections*, and websites such as *TKI. org*. Units by the *Australian User Friendly Co.* and lesson plans by *Curriculum Concepts* and other private NZ publishers were mentioned. Software mentioned included *Microsoft Magic School Bus, Anglican Multimedia, and Encarta*. Those near Colleges of Education (Massey, Dunedin, Chch) mentioned borrowing resources from them.

Schools in Canterbury mentioned budgeting to hire the *Science Alive* museum resources and outreach programs. Central South and North Islands mentioned as a resource their....*excellent Science Advisor*.

Many regions expressed the desirability of having resource kit.

Resource packs to hire/buy would be great for small schools.

In the days of the old Dept of Ed Booklets the boxes of resources supplied by the Educ Board were very handy, e.g., contained chemicals, torches, pulleys, etc.

Simple, robust class kits...a great supplement to planned science units as it keeps thinking about science and scientific observation and hypothesizing more readily in the fore of students minds.

Teachers mentioned the difficulty of maintaining the supply cupboard.

Keeping up the regular supplies of physical materials can put people off—often fiddly.

We have nothing!

Lists of supplies on hand ranged from 10 pages of computer printout from a decile 10 school reporting having sufficient supplies to a decile 2 school reporting having absolutely nothing and comments such as...

All that we have that is of value is our children, a BOT with tons of good intentions but no finance...

Some schools noted that they did have some *magnets and mirrors*, but many listed magnets and mirrors as things they did not have!

Some of the equipment teachers listed that they did not have:

- *beakers, bulbs, bulb holders, boiling & cooking equipment,*
- *cogs, compasses, convex and concave mirrors, circuit boards,*
- *dishes, gears, heating elements, iron filings, levers,*
- *magnets, magnifying lenses, measuring jugs, metal samples, mirrors,*
- *ovens, plastic mirrors, prisms, pulleys, retort stands,*
- *scales, scientific hardware, sinking/floating materials, springs, switches,*
- *thermometers, torches, tuning forks, wire and batteries, wheels, wood samples*

One teacher noted a difference in confidence levels between male and female teachers, and a resultant different priority for gear. Typical comments from females:

Many—especially women— have little confidence in this area. (Female)

If you don't have working knowledge you don't feel comfortable teaching it. (Female)

I borrow an electrical test meter from my partner. (Female)

Comments from males were slightly different.

Get support staff to find the resources needed and then its all go. (Male)

Kids will find a lot of the gear. (Male)

It's a matter of 'just doing it'. (Male)

Since I consider these subjects are very important I ensure material is available when needed. (Male)

No schools listed any outside reading material on these topics suitable for use by pupils age 8-11, but several wanted such resources, mentioning the keen interest and reading ability of these pupils wanting...

Additional resource books at the high interest 8-11 reading age.

...more support material for students, e.g., information texts at Primary School reading level.

What would you ideally like to have? Many responses were brief.

A well-resourced school.

Physical science equipment of any sort.

Reading books for children related to these areas.

Want Any lab gear.

Any hands-on material.

Some also mentioned needing a budget for consumables and disposables.

...we are always in need of consumables.

Some respondents echoed the recommendation of others noted above:

Batteries, bulbs, circuit materials, pulleys, cogs, gears, magnifying glasses, -every primary school should have purpose built science lab so that children could benefit from real science learning and teaching environment.

We need...

A science room where classes can visit and all resources are on hand.

Many teachers simply wanted *lists*, including lists for...

- *equipment available for loan / purchase*
- *personnel available in each region*
- *complete lesson plans*
- *videos, CD ROMs*
- *internet sites*
- *reference texts*

Many wanted units which at least covered the core curriculum requirements.

- *Planned units of work so less confident teachers can 'pick up and go'.*
- *Trial units would be fantastic.*
- *Unit materials like the old Dept of Ed guides.*
- *Units which include background information for teachers are great.*

There were several requests for resources in Maori or related to Maori themes.

Many teachers wanted more visual resources, posters, big pictures, videos...

Books and videos which spell out all the fundamentals, e.g., what a reaction is, and give examples of activities which can be done.

Videos can be really powerful—I have none on Material or Physical World.

I say books and videos in preference to CD ROMs and Internet because books and videos are immediately available to audiences of approximately 30 whereas CD ROMs and Internet, although useful, are only available if the teacher and classroom have computers and computer knowledge.

Some teachers wrote at length, e.g.,

Points raised at discussion with colleagues:

Children today do not appear to have the same opportunities or encouragement to explore physical/material science at home/out of school as in the past. E.g., taking apart old radios, machines/making circuits.

When given opportunities at school children often want to play and do not approach lesson sensibly (often appears more so with boys!!!)

Time-frame does not always allow for free discovery (in-depth) and attitude and approach can affect teacher negatively in these strands. Would be useful to have a Resource Pack of leveled 'user friendly' activity cards which children can work on independently or in pairs at science stations permanently set-up in classrooms.

The resource wanted most was summed up by a teacher in Wellington:

\$ \$ \$ \$ \$ \$!

Teachers had good ideas of the equipment they wanted. They also suggested solutions to the problem such as a library of equipment kits. Some mentioned other problems that made it difficult to teach such as open plan classes or wide age ranges.

The resources survey strongly indicated that many schools were under-resourced for teaching the new physical science curriculum and struggling to give meaningful lessons. At the same time they clearly indicated the under teaching was not due to themselves or their pupils. Both teachers and pupils were excited about physical science and wanted to learn or teach it.

Questionnaires were used in the early part of the study to get feedback, information, and comments from teachers and students using the workbooks over a few terms. In primary school the emphasis is on the development of the whole child more than learning anything 'testable' in chemistry and physics. It was important to find out whether or not the books served the broader purposes of primary education, the integrating as well as contextual strands of the curriculum.

7.1 Methods-Questionnaire

Class sets of books were sent to the volunteer teachers and then the teachers were on their own. One teacher (the only one using Workbook 2) was supplied with a complete kit of equipment for the workbook activities. Otherwise, the teachers had no further supporting material, people or information other than the normal support available to all schools and an 0-800 'Helpline' number printed in the books. (None used it.)

The workbooks were sequential but generic and more than one book could be used in any given year, or any book could be used separately at any grade level. Pupils could read them with minimum supervision. The activities were designed to focus pupils' attention and to stimulate interest, motivate discussion, and encourage further investigation. Most of the activities were meant for groupwork. Written exercises were included to reinforce important concepts. Question formats were mixed. Some questions did not require definite answers, some did, and some were open-ended to stimulate discussion. Some required use of new vocabulary, some required numerical statements. Recording data was required as well as sketching setups.

The activities were low-tech, requiring only basic materials, and the pupils needed to assemble some things for themselves. Chapter topics included: *materials, magnets,*

light, earth and its neighbors, matter, heat, electricity, types of changes, water and changes of state, forces, energy, simple machines and saving our earth. They were meant to be written-on and coloured-in so the covers and the pages were printed in black and white. The workbooks varied from 106 to 136 pages in length. They were soft-covered and small 170 x 250mm in size.

Teacher guides enabled anyone to teach the material. Chapter headings were organized into the following areas: summary charts, rationale, overall objectives for each chapter, background information, main concepts for activities, specific objectives for activities, vocabulary of keywords, materials required for activities, suggested time frames for lessons, teaching suggestions, enrichment activities, and review exercises. They provided background material on the topics, outlined important concepts and objectives, and suggested teaching strategies. Most of the background material was meant for teachers' interest only.

The learning sequence was generally that of...i) exploration, ii) assimilation and iii) application. Review exercises to consolidate learning and optional enrichment activities were also provided. There were reviews, but no tests or assessments.

There was diversity in the sample. Students ranged in age from 7 to 13. The group included a one-room South Island area school of 27 pupils age 7 to 12 and class level Y4 to Y8. There was a large South Auckland metropolitan double class of 65 in Y8, ages 12 and 13. There was a South Island city school with a Y5 class of 30 and a West Coast Y6 class of 20. All schools were public. Two teachers were male.

Toward the end of the trial period two questionnaires were sent to the teachers, one for them and one for their students. The response to either was strictly voluntary, even after using the books.

The teacher questionnaire was seven pages long and consisted of a variety of types of questions including fill-in-the-blank, comment on, and semantic differential scales. Questions were organized in seven categories:

1. Can the Year 5-8 physical sciences be taught by someone with no prior interest or experience in the subject using only these student workbooks and teacher guides?
2. Is a student text/workbook and teacher guide the optimal medium for teaching this subject matter?
3. Aside from meeting and exceeding the contextual and integrating strands of the NZ curriculum, does this material provide opportunities for students to develop other skills as part of the broader educational and growing process?
4. Is the material adaptable to a variety of teaching strategies?
5. Do schools have the necessary equipment to carry out the activities?
6. To what extent does the practice of using student-made equipment in the activities satisfy the technology component of the curriculum?
7. What are some comments of students and teachers about the material?

The pupil questionnaire consisted of the same variety of question type as the teacher questionnaire— open ended, closed answer, scaled choice, etc. It sought to find out what features they liked, what features they used, what features they would change, etc. It also asked what aspects of science they liked, what they did, how much of the book they completed, and so forth. It asked if they had enough resources. It asked what they remembered in hindsight—the pictures? the group work? the teachers voice? what they did? what they said? what was on the board? what someone else said? It asked for their overall rating and comments. It was voluntary, but all the children filled them out. For fun it also included a ‘smiley face’ scale which was intended to give the questionnaire a light-hearted (non-test) appearance.

Pupils were not identified, but to reduce the likelihood of silly answers (Sex: yes; Race: 2K, etc) pupils were asked to state a first name and age only. Students were treated as book reviewers, and asked only their opinions -of the book and the activities - not questioned on their recall of the content. The privacy and anonymity of the schools, the teachers and the pupils was maintained at all times.



7.2 Results—Teacher Questionnaire

The comments of teachers in the early book trials are grouped below by topic.

1. Can the Year 5-8 physical sciences be taught by someone with no prior interest or experience in the subject using only the workbooks and guides provided?

This question was addressed by Teacher Questionnaire (TQ) Items 6 e and f. All respondents answered 'yes' to both these items with additional hand written comments including, 'great', 'good, clear explanations', 'good layout', 'very good', 'the material is prepared for the teacher', and 'good for someone without a practical background'.

2. Is a student text/workbook and teacher guide the optimal medium for teaching this subject matter?

This question was addressed by Item 7 in relation to the common practice of using photocopied handouts from mastersheets. There were 10 components to this item with a semantic differential scale of responses values from 1 (disagree) to 5 (strongly agree) for each. The average response was 4.7 implying the workbook format was well-liked.

3. Aside from meeting and exceeding the contextual and integrating strands of the NZ curriculum, does this material provide opportunities for students to develop other skills as part of the broader education and growing process? Other skills include literacy, reading, writing, spelling, speaking, using numbers, observing, problem solving, listening, questioning, organizing, planning, cooperating, creating and working with hands on.

The question thus had 15 components with semantic differential responses from 1 (disagree) to 5 (strongly agree) reflecting how well the books provided opportunities for developing the above mentioned skills. The

average score for all components and respondents was 4.4 indicating an affirmative response overall for the books provided.

4. Is the material adaptable to a variety of teaching strategies?

Although all classes trialled only Workbook 1, the pupils ranged in age from 7 to 12, the classes from Y4 to Y8, and the students worked independently or in pairs or groups. Some classes which worked in unison were composite classes on two or three-year cycles with an age range of five years, and some were single-age classes on one-year cycles. Each of these schools was different and by necessity used different teaching strategies. All the responses on this question were in the affirmative.

5. Do schools have the necessary equipment to carry out the activities?

This question was asked on both the Teacher's Survey and the Pupils' Survey. The pupils were forthcoming about the lack of equipment. There was a good agreement between the pupils and the teachers as to whether they did or did not have enough equipment. The majority replied negatively.

The Teachers indicated they had enough equipment for the activities they tried, but tended to choose only those activities from the book for which they already had some equipment. In all cases very little of the book was attempted. No class completed the whole book. Most chose just one activity from the book. Pupils invariably answered "No", "Usually" or "Sometimes" to the question, "Did you have enough equipment?"

6. To what extent does the practice of using student-made equipment in the activities satisfy the technology component of the curriculum?

This was a feature of the books, but not addressed in the study and included in this list only for completeness.

7. What are some comments of students and teachers with regard to this material?

About the pupils the teachers said,

...the children enjoy it, ...they liked the idea of 'ownership'

...very topical and local and the children can relate to it

...used to extend the older children

About the content...

...all the facts were covered

...having pictures of metals in front of the children was really good

...ideal topics

...balance of information and activities

...especially useful for someone without a practical background

...very beneficial in the science field

About the overall impression...

...I think the book is excellent

...easy to use

...excellent activities, ...clear vocabulary

...clear print and layout, ...clear diagrams, ...clear explanations,

...interesting activities

About the workbook format...

...being able to write on ready made charts saved a lot of work and time

...the concept of a write-on booklet is good as it saves time and

...provides a great medium for structured responses

...saves a lot of planning

...good to have the colouring aspect

About use on school camp...

...Earth and It's Neighbors would be really good on a school camp

(observing the night sky and recording the moon chart several nights)

About use in different situations teachers said,

...suitable for more than one class level

...geared to the appropriate level

...can use for homework activity

*...It is very convenient and saves a lot of (time) planning, and can
add to or delete as required to put our own info and ideas into it.*

*Everything is done for you, interesting activities, good ideas suitable
for more than one level. Keep the black and white format.*

Teachers who trialled the books felt confident and enjoyed teaching physical science with them. No further training or outside assistance was needed and the teachers added to the material with content of their own. The workbooks were reported to save time and money. Some classes added a blank 1B5 book for writing up projects during the year. Pupils liked the books and were positive about the science. The availability of basic lab equipment varied from school to school.

In the first term of 2000, in the first few months the books were available to the public, hundreds of schools across the country including full and contributing primaries, intermediate, secondary, public, private, hospital, religious, area, sole charge, Te Kura Kaupapa Maori and home school associations requested the series.

Below is a copy of a fax received from one such school, a large public full primary.

FAX NO: 02-201 2200 Phone 201 0384
SUBJECT: other strands No. Pages

MESSAGE

Teachers at our school have loved the Physical Workbooks. Well done.
When are books coming out which cover the other science strands?
C. Hiram

7.3 Results—Student Questionnaire

The student responses are grouped according to topic and question.

The Student Workbook

The students liked their own book and almost all took their book home. The students were nearly unanimous in circling 'yes' - they found the writing and illustrations clear, and they did write and colour in their book.

What do you like about science?

It could have been anticipated that responses within any given class might be more similar to each other than to those from classes in different parts of the country. But across the board within any class and across the country the most common response to 'What I like about doing science?' was,

Doing the experiments.

This was written in several forms, e.g.,

Doing all the stuff with it.

Playing with the gear.

The next most common response was learning things not known before, e.g.,

You learn more stuff.

What topics in science?

Students mentioned light, magnets, space, electricity, and almost all the topics covered. But when asked what would they like to learn more about, they invariably answered,

Animals.

Illustrations

The students indicated that the pictures helped them understand the content

and showed them how to do the activities. The most common response to what the children liked about the book was the 'illustrations, drawing, artwork, pictures'. They also said they liked being able to write on the book and virtually all liked to colour it.

Cannot see the board or hear the teacher

Almost all agreed that sometimes they could not hear what the teacher was saying and they could not make out what was written on the board at the front of the room. The books helped overcome these problems.

Books vs handout sheets

60% reported their handout their sheets get lost. About 50% felt information in books was usually more important than information on handouts. All but one student felt that when they write in their book they can see what they have accomplished and 100% replied yes, that they could look back in the book to remember what they had done.

Work in pairs independently from teacher

Teachers commented that books enabled the children to work independently (with guidance) and confirming this 90% of the students responded yes, that since they had a book they could get on with the work when they were ready.

What do you remember now on reflection?

Students were asked to take their time on this question. The teacher was asked to read it slowly aloud to make sure the pupils understood it and took time thinking about it. The responses of three classes were combined. One class was from the North Island, aged 12-13, Year 8 using Book 2 and the other two classes were from the South Island, aged 9-10 using Workbook 1. They were all public co-educational schools. The response by percent to Question 21 is shown in Table 7.3 and the highest percent in each category has been shaded.

Table 7.3

Q 21 What do you remember now about using the book?

I remember...	Percent “not much”	Percent “some”	Percent “a lot”	Number of responses
...what I said	46	43	12	68
...the activities we did	7	46	47	72
..what was on the board	25	21	15	72
what other students said	33	50	17	70
...what I wrote down	33	43	24	75
the pictures in my book	19	38	44	68
.the reading in my book	29	48	23	66
...what the teacher said	12	44	29	68

To summarize the responses to this question,

I remember a lot of ...

what we did (activities, experiments)

what I saw pictorially, i.e., the pictures in my book

I remember some of...

what I heard, what other students said and what the teacher said

what I wrote down

what I read in my book

I remember not much of...

what I said

what was on the board (but nothing on the board in most cases)

Like group work?

The response was lukewarm about working in groups - many answered ‘no’ they did not like it, and the majority liked it only sometimes. The pattern shown below is typical and reproduced without alteration from an actual returned response. Question 5 stood out from the rest.

Name: Desiree

Age: 13

Grade: Yr 8

1. Was the book clear? ☒ yes / usually / sometimes / no
2. Did you write in the book? ☒ yes / usually / sometimes / no
3. Were the illustrations clear? ☒ yes / usually / sometimes / no
4. Did you like colouring in the book? ☒ yes / usually / sometimes / no
5. Did you like working in groups? yes / usually / sometimes ☒ no
6. Did you complete the activities you started? ☒ yes / usually / sometimes / no
7. Did you have enough equipment? yes / usually / sometimes ☒ no
8. Did you like having your own book? ☒ yes / usually / sometimes / no
9. Did you ever take it home? ☒ yes / usually / sometimes / no
10. How much of the book did you do? a little / some ☒ a lot / all of it
- ...
16. What I like about doing science is: Experimenting
- ...
22. Your comments: The Book is so much better than working on sheets

The workbook was meant to encourage individual accountability through recording of data and writing responses, but at the same time allow working in groups of two or three to foster discussion, exchange of ideas and sharing of skills. It was not clear why pupils did not like group work.

One of the first sets of questionnaires returned was from the group of 12-13 year olds who had used Book 2 on Electricity. The author had supplied all the equipment listed in Table 16.1. For example, 16 battery holders had been sent, so it could be inferred that for a class of 29, the students would have had to share equipment. The teacher had written that the pupils worked in pairs.

Students ages were known from class information. First names were written on each questionnaire so gender could be deduced and matched to response. From that an inference could be made between about gender and group work preferences.

The responses (28) about group work were tabulated with respect to gender and the results are displayed in Table 7.3a.

Table 7.3a Gender vs Group work

Q 5 Did you like working in groups? yes / usually / sometimes / no

Do you like group work?	Frequency Yr 8 Boys Age 12-13	Frequency Yr 8 Girls Age 12-13	Percent of Total Boys + Girls Age 12-13
Yes/Usually	11	2	46%
No/Sometimes	6	9	54%

The response to group work was mixed. It appeared the bias could be related to gender. One cell had a frequency of only 2, below the threshold for chi-square analysis, so all the responses from two more classes were added in. These were from the next two schools which were classes of 9 and 10 year olds in Year 6, and the frequencies are shown in Table 7.3b. Since the number of degrees of freedom is 1, the Yates correction was applied (Burns, 2000).

Table 7.3b Gender vs Group work

Q 5 Did you like working in groups? yes / usually / sometimes / no

Do you like group work?	Frequency Yrs 6 + 8 Boys Age 9-13	Frequency Yrs 6 + 8 Girls Age 9-13	Percent of Total Boys + Girls Age 9-13
Yes/Usually	29	10	54%
No/Sometimes	13	20	46%

$$(X^2_{\text{boy/girl}} = 4.11, df = 1, N = 72, p < .05)$$

There appears to be a relationship between gender and liking or disliking group-work which is statistically significant at the .05 level. This may be related to equipment shortage, but could be investigated further.

At the end of the student questionnaire was space for open comments. Typical responses are listed below.

“It is a very good book. You learn a lot out of it. You should make more.” (Age 9)

“I think these books are great! I love them.” (Age 9)

“I think this book is awesome.” (Age 12)

“This book is very good. There is nothing you don’t learn from it.” (Age 10)

“What I liked was playing with things you’ve never played with before.” (Age 10)

“I liked working stuff out and colouring in.” (Age 12)

“I liked colouring in and doing experiments.” (Age 11)

“The book is so much better than working on sheets.” (Age 13)

“This book is better than boring old science test. It is fun.” (Age 9)

“I enjoyed making the circuits and testing them out.” (Age 12)

“This science book was very good.” (Age 12)

“You get to work things out.” (Age 10)

“I think the book is a good idea to have and it is very educational.” (Age 13)

“What I liked best in this book was that there was some interesting experiments to do, and also I liked the black and white pages so I could colour in the book after doing an experiment.” (Age 12)

“I love this book. It is great and fun for learning.” (Age 12)

“I like it because I get to write in it.” (Age 9)

“I really liked the book, it would be cool if you made another one.” (Age 10)

“I liked the book quite a lot because the pictures for colouring in and I liked Chapter 3, it was pretty good.” (Age 9)

“The book was so understanding and clear, I hope I get another one before school finishes.” (Age 12)

“Your book had cool pictures.” (Age 10)

“This book is very well illustrated.” (Age 10)

“The book was really good.” (Age 9)

“I liked the pictures. I also thought that the bigger print was easier to read.” (Age 12)

“These books help you better than other books.” (Age 10)

“It was a very interesting book and I had a lot of fun learning.” (Age 10)

“It is fun and I like making things with my own hands.” (Age 12)

“It was fun doing the work in the book.” (Age 12)

“You find out things you didn’t even know about.” (Age 9)

“I liked the fact that it was black & white so I could colour the book in and it was easy to write answers because we did not have to copy out the question.” (Age 11)

“I liked the science workbooks because they explained why it worked, how it worked, and how to do it.” (Age 11)

“I think the book is a great investment and I would recommend it to other schools.”
(Age 10)

Pupils were more apt than their teachers to state they did not have enough equipment and did not do many portions of the book. Girls in coed schools were lukewarm or negative about having to share equipment and work in groups. The pupils enjoyed many aspects of the books, and overall did not consider the information from books more important than information from handout sheets. They remembered what they did and were invariably positive in their comments about the books.

Teacher and pupil comments indicated pupils were eager to learn and enthusiastic about physical science and liked doing activities and experiments. Students said they remembered what they did, the pictures they saw, and the statements they heard from other students as well as the teacher. The teachers responded to the enthusiasm of the pupils by becoming more interested in teaching physical science.

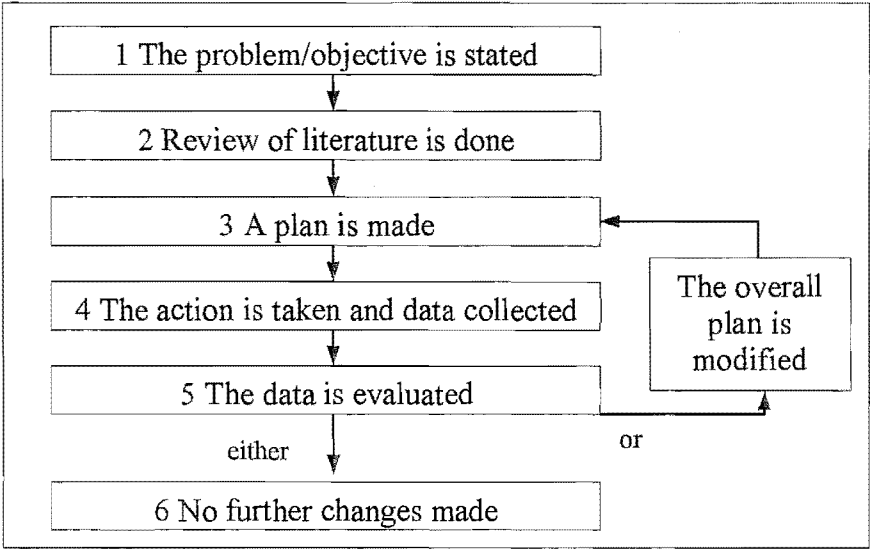
This chapter provides a brief description of the method *action* research which is used to complement *survey* research and *questionnaire* research. It is similar to keeping a lab record as work proceeds in a lab. Teachers kept journals while using the books of this study. It is a good research method for a classroom environment.

8.1 Methods—Action Research

Action research is a pragmatic, utilitarian, informal and naturalistic investigative procedure useful in educational settings for collecting and assessing information with regard to classroom practices. Data are collected by the teacher as the person with a firsthand view of the existing situation. It can confirm and augment, or triangulate, information collected using surveys and questionnaires. It can provide a way to ‘probe below the surface of the obvious and taken for granted’ (Ball, 2000). It is a good ‘reality check’, but takes time for the teacher participant to do.

The data recorded may be organized in a journal and may include brief or extensive entries regarding observations and interactions, transcripts or quotes, copies of material generated or used, samples of student work and so forth. For this study teachers were also asked to take photos of the classroom during the activity. There can be a cycle of steps involved in action research, as shown in Fig 8.1.

Fig 8.1
Action-research
flow chart



The four basic characteristics of action research are: (Burns, 2000)

1. It is situational, it involves diagnosing and solving a problem in a specific context
2. It is collaborative, researchers and practitioners work together
3. It is participatory, team members partake in the action
4. It is self-evaluative team members modify and evaluate with a view to continual growth and improvement

It is a qualitative research method, but produces insights which can inform quantitative research. It enhances three-way communication and sharing of ideas between, say, pupils, teacher and researcher. It fosters cooperation and stimulates creativity and critical thinking. Although the researcher may pose the question, the teacher is the professional whose skills bring the research forward. One drawback is that since it is part of an ongoing process it invariably takes time—from a term to several years, and for that reason is not reproducible (Burns, 2000).

For the purposes of this study it was the most cost-effective method of obtaining information without disturbing the normal routine of the classroom. More discussion with the participants, even if outside the classroom, may have lead to a greater class time focus on the subject than normally would have been planned. The researcher should have a neutral effect on the participants.

One objective of the study was to gain insight into *if, when, what* and *how* physical science was taught. Another was to learn about the usefulness of the resource material provided or any other material used. The teachers collected the data over the year and forwarded it with samples of student work at the end of the year.

None of the teachers had ever been involved in such a project or action research before, but no prior experience was needed. The postulate that the teacher is the expert in the classroom was adhered to. The data and insights from teachers who participated as well as those who found they could not participate was in every instance superb.

A simple model for field trial action research using new physics books in a classroom is described by Baimba (1993). In this study the author, a trained physicist, prepares a teaching module which is implemented by the participant teachers using action research journals. A six-lesson module was used at the junior secondary level. The teachers participate actively, not passively, and feed back into the module after trialling it. This is a typical action research model (Schon, 1987).

Constructivism may be seen as a theoretical basis for action research. The participants include the students, the teachers and the outside investigators and are all viewed as though traveling interdependently along paths of discovery and learning (Northfield, 1999). Constructivist theory goes hand-in-hand with action research as both involve cycles of discovery, clarification, checking, etc. (Driver, 1985). This is true for education research generally and for teaching and learning in science where phenomena can be discovered, clarified, rechecked and 'rediscovered' with the refinement of understanding (Novak, 1978). A constructivist approach is often used in teaching primary science as well as in teaching primary science teachers (Bell, 1993). The recorded views of participants prior to trial may be a useful starting point for reflection (Kellehear, 1993).

Simple concepts introduced at the primary level need time to mature over the following years. Content is viewed within the larger perspective of the entire intellectual life of the student—within and without the classroom (Ausubel, 1968). At the primary level overarching achievement outcomes and pedagogical strategies may be open-ended and thus subject to continual refinement and redefinition.

The use of grounded theory (i.e. journals, photos, workbooks or other data sources) in reflection may help clarify the strengths and weaknesses of the process (Glaser, 1967). What works, for whom, and why can thus become the data which feeds into the process as it evolves, and should do so for it to succeed (Delamont, 1976).

The action-research approach may be viewed as from the humanist branch of philosophy which empowers participants (both pupils and teachers) by allowing them to be motivated by intrinsic rewards such as personal satisfaction, growth, accomplishment, and mental stimulation (Carlson, 1987; Strauss, 1990).

Participants

The first dozen or so teachers who responded to a notice in the Education Gazette plus a school which had won a book draw from the Resources Survey and the Canterbury Homeschool Association comprised the action research study group. They were distributed well geographically and across several socio-economic strata, giving demographic diversity. The number of participants was limited by the cost of the books and teacher guides which needed to be supplied. Some schools had several classes at different levels with 30 pupils per class. Prior to joining the project each teacher was sent a sample of each book at each level and information about the study. The teachers chose the book they wanted to use and indicated how many they needed.

Use of the material was at the discretion of the teacher with no interference at all. They were given as much time as needed—up to two years. They were under no obligation to use the books provided. They were free to use any other resource. They were to do whatever was best in their judgment for their students. All teachers signed informed consents as did the students and caregivers. The pupils were given opinion questionnaires at the end of the trial.

Action research is conducted in real-time. Some primary schools are on two year cycles. The time involved caused this project to be extended longer than planned. Action research as a method is excellent, but unless the researcher can control the timing of events to some extent, it is more practical for research which has flexible, negotiable or indefinite start and end points.

The teachers were asked to photograph their class in candid action shots. This gave a vivid picture of what they were writing about. Some participants sent posed photos or standard class photos. Those that sent action photos allowed the audience (researcher or reader) to see the class through the eyes of the teacher. Their words came to life in this way, and seeing what had been described was an interesting and rewarding part of the study and the photos were valuable for the study. The results are presented in part 8.2.

8.2 Results—Action Research : Teacher journal entries and student reply sheets

A summary of the journal entries by teachers in the study as they were kept over the year is presented below. Direct quotes from the teacher journals are italicized. The comments of students from their reply sheets are also included and italicized.

8.2 (i) Schools which dropped out before starting

Two teachers (Schools A and B) who had intended to participate and had requested and received books, signed informed consent forms and so forth, dropped out of the project before even starting. The reasons given revolved around the ‘usual suspects’: lack of time and lack of equipment.

School A

The first of these was a suburban Decile 10 school of 450 pupils. The class consisted of 29 pupils ages 11-13. The teacher was well-respected and had many years teaching experience. The handwritten explanation included the following:

- *As a Full Primary school we do not have timetabled Science on a weekly basis as Intermediates usually do.*
- *I had hoped that having the Student Workbooks would encourage me to do Science each week, even if only for 30 minutes.*
- *This has proved to be impossible due to the pressure of accommodating all the other curriculum areas, e.g., Language (Oral, Written, Visual, Reading, Handwriting), Maths, Social Studies, Technology, German, Taha Maori, Literature, Health and P.E., Music, and Art.*

- *Our Year 7/8 students also go to Manual at the nearby Intermediate School for 2½ hours per week and there are 20 minutes of travel each way which is 'dead' time.*
- *In a term of 10 weeks we are expected to complete a unit in Social Studies, Science, Technology and Health.*
- *As we only have three afternoons to use (Mon, Tues, ½ Thurs), this is a challenge for us.*
- *Orchestra meets for an hour each Wednesday afternoon and sport is on Friday afternoon.*
- *This means we can do 4 units a year- one from each strand.*
- *Logistically you can see that Science can only be given 6 afternoons (8 hours per year) in real time.*

The interpretation is as follows:

$(2\frac{1}{2} \text{ afternoons} / 4 \text{ Curriculum Areas}) \times 9 \text{ weeks} = 6 \text{ afternoons per term.}$

Four units per year = one unit of Social Studies, one unit of Science, one of Technology, one of Health.

An afternoon = 1:30—3:00pm.

Six afternoons \approx 8 hours per year.

Hence, this leaves 8 hours per year for 'Science'.

This 8 hours is subsequently divided up by 4 subject areas: planet earth and beyond, and the living, material & physical worlds.

So, if biology and geology/outer space are limited to 2 hours a year for each (which is unlikely),

there are only 2 hours per year each for physical world and material world.

School B

The other which dropped out after signing up and receiving books but before starting was a rural decile 3 school of 3 teachers and 60 students aged 8-13. A note stated that the school did not have *any* equipment, even magnets with which to do any of the activities, and they therefore could not participate.

A registered teacher with thirty years experience at all levels of science teaching - Primary, Secondary and Polytechnic - offered to lend a hand. She offered to drive out from Gisborne to teach science once a week at the school for free, and even to bring equipment from a local high school. But after visiting once agreed that the task was impossible, citing a too great a lack of basic equipment and the difficulty pupils would have starting Book 1.

Time extension sought

At the end of the first year, 5 teachers returned the data they had collected. The other 5 teachers wrote to say they had not been able to start teaching physical science for one reason or another, and ask if they could they please have an extension of another year. The extension was granted.

Schools C, D, E, F, G Reasons cited as barriers to teaching

After a further 6 months i.e., a total of 1½ years, it appeared that the remaining half of the Study Group would probably not be able to make a start even if given a full two years, so a brief questionnaire was sent to find out why. Four of these were returned. Each teacher indicated they felt that physical science was important and should be taught prior to Year 9 at Secondary School where labs, equipment and specialist teachers are available, but checked off the following points:

- ☒ Most schools do not have the equipment needed to teach it.
- ☒ Almost none have any dedicated space for teaching it.
- ☒ There is no time to teach it.
- ☒ Teaching it means sacrificing other activities from which the students would benefit.
- ☒ It is like teaching cooking without a kitchen.

☒ *Also, its too abstract*

In a follow up discussion with one of these teachers who intended to start, but did not, he said he felt the increased level of abstraction and requisite mathematics swayed teachers away from teaching physical science toward teaching biological science if there was a choice.

He mentioned concepts such as 'force' and 'inertia' and activities such as drawing ray diagrams to illustrate the abstract, mathematical aspect of physical science which is not encountered in life science.

He noted that with Bulk Funding equipment was not provided and purchases had become discretionary.

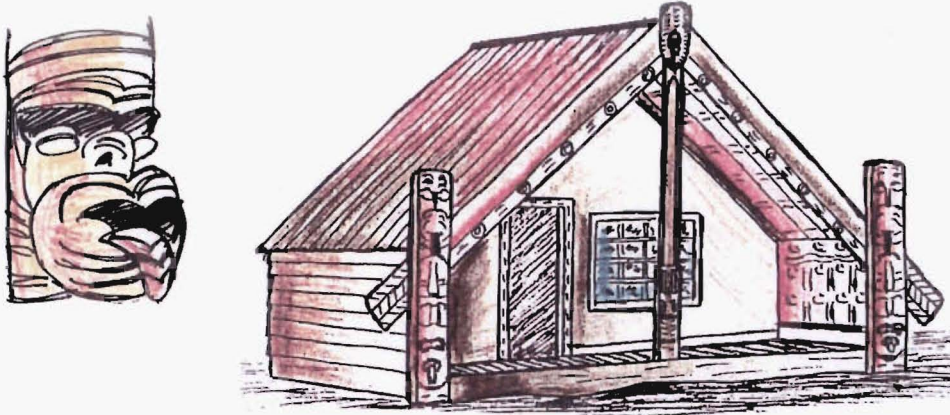
He commented that pupils cared about conservation and environmental topics, and these tied in with life science and also that resources in this area had become more readily available in the last few years, so more time was allotted in this area.

Schools which did start

School 1: *Contributing Primary, Yr 0-6, Decile 1, 320 pupils; Year 3/4, 28 Students*

This was a Year 3/4 class with pupils ranging in age from 7 to 9 and a median age of 8. The age was appropriate for Student Workbook 1 which the pupils used. There were 28 pupils in the class and the teacher wrote...

*All the children thoroughly enjoyed using the workbooks—
made them feel 'special' and 'grown up'.*

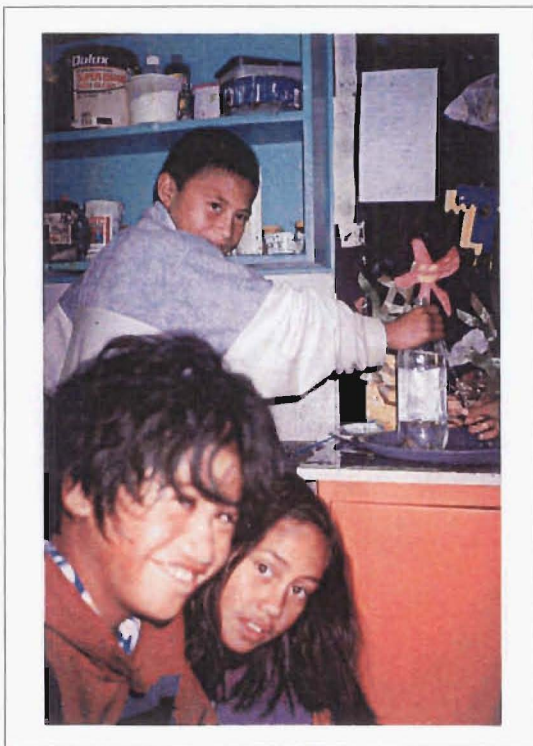


Common material: wood

Note: All colouring and work shown is original student work.

The teacher reported that the school needed equipment of all kinds and that she used her own money for resources. She listed the science supplies on hand for teaching this part of the curriculum as:

- beetroot juice
- newspaper
- card
- scrap and junk materials
- toys bought at garage sales
- a borrowed multimeter



Photos taken by the teacher of the class doing an activity suggested in the curriculum guidelines for physical science show the pupils are eager to learn and enthusiastic.

Like most primary classrooms this one does not appear to be equipped for laboratory-type activities.

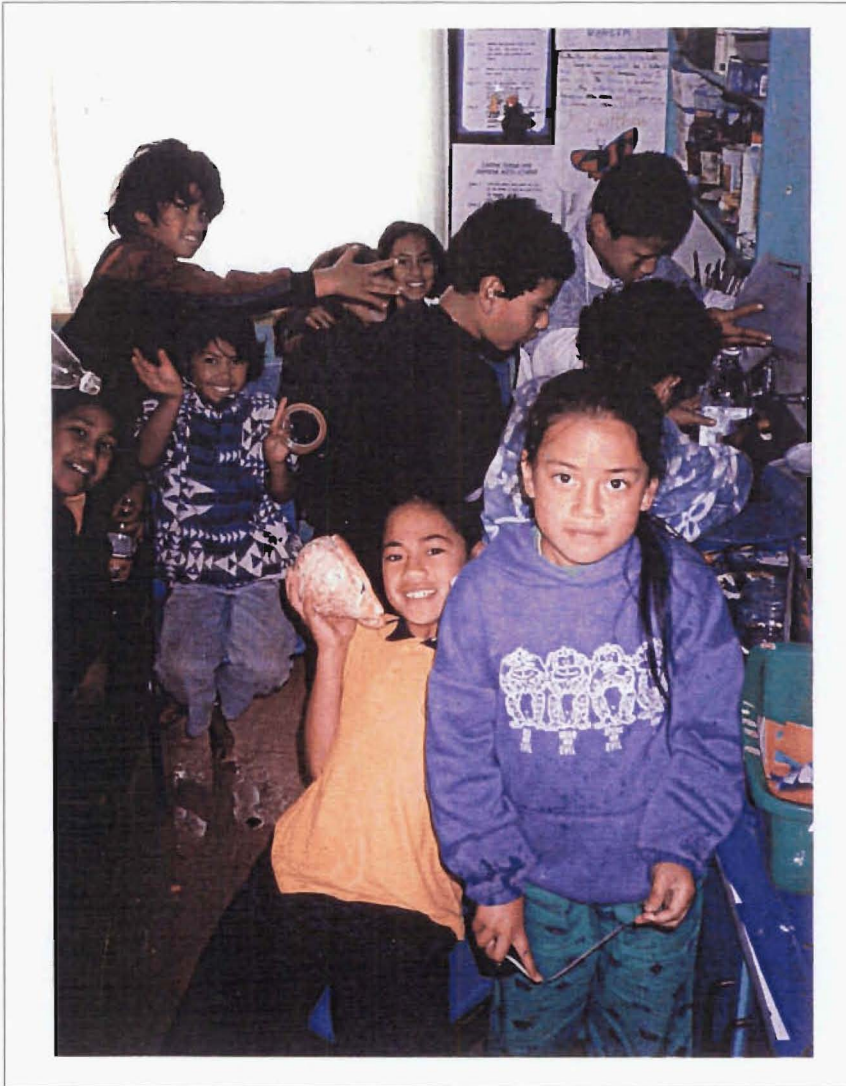
School 1

There does not appear to be a demonstration or work table, student work tables, or an easily accessible sink.



Two activities are being done at the same time.

1. The children in the background are working on a water pressure experiment.
2. The children in the foreground are doing a science unit, 'Sound'.



School 1

The teacher wrote that they did not have batteries, magnets and other equipment and needed support material for both student and teacher. If supplies are insufficient or the workspace cramped, all the children may not get 'hands-on'. The larger children may push the smaller ones out of the way and take over the experiment for themselves.

The teacher is doing an excellent job delivering the full curriculum and the children are obviously enjoying learning despite the lack of space, equipment and facilities.

The pupils liked filling in the tables, coloring, and the discussions. Oracy and literacy skills were emphasized school-wide and were part of all units.

Oral Tradition

The teacher commented on the importance of

- ...*'inter-pupil' discussion...*
- ...*children talked about the properties of the wax and pencil crayon they used to colour in the diagrams!*
- ...*they asked about the iron we ingest and iron as a material*
- ...*children becoming more confident during discussions.*
- ...*children becoming more articulate*
- ...*discussion is necessary and helps consolidate aims.*

Piaget and other European investigators also stressed the importance of consolidating aims or 'making concepts concrete', but invariably this meant writing them on paper. From the Pacific Island perspective this teacher observed, it was at least, if not more important, to make ideas concrete by formulating them in speech.

Data Recording Skills

The teacher gave 'two ticks' (✓✓very good) to the ...

- ✓✓ *Tabular activities familiarize Pre-Sec School children with the importance of results and records in scientific investigations.*
- ✓✓ *Tabular format in Pre-Sec Sci Wkbk 1 is very clear. The children enjoyed the completing and also colouring-in 'bits'.*

Students had learned how to organize data in tables. Several weeks later, when the pupils were asked to list materials and their properties for several toys, the students immediately set up a tabular form to fill in just as they had seen and done in Workbook 1.

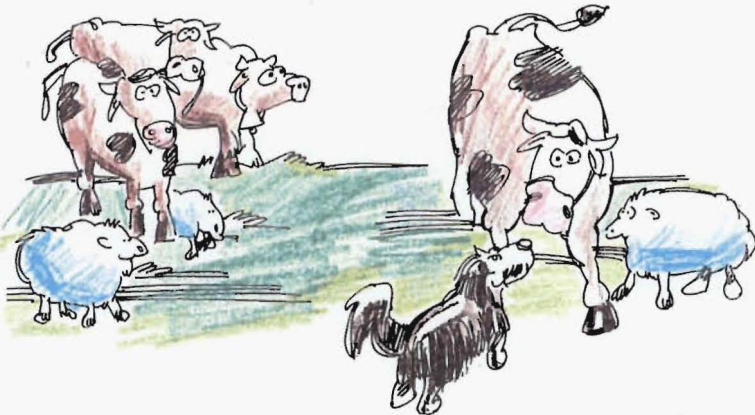
The students listed,

...toys they had had, seen or wanted, writing their own tabular record obviously learned from the book's layout....

The students displayed a large vocabulary and gave an insight into North Island life.

School 1

ACTIVITY 1 *Grouping Objects*



1. Observe the objects given to you. Fill in the table.

Object	Material used to make it
bat ✓	Straw ✓
tub ✓	Plastic ✓
Cicada ✓	Keratin ✓
Skeleton ✓	Plastic ✓
Leaf ✓	Plant fibre ✓
Foil ✓	tin ✓
Crayon ✓	wax ✓
net bag ✓	nylon ✓
Paint ✓	oil ✓

Tino pai.

It would be natural to assume that tin foil is made of tin. Instruction was in English, but the teacher used stickers and comments in Maori and Samoan, e.g., ‘tino pai’.



Science taught by theme chosen by school

In referring to public schools, the practice had been to teach science as part of a theme called a context. The context comes first and the science comes out of that.

The teacher wrote,

*....most pre-secondary science is topic-based,
and the topics vary from school to school..*

At her school there was an interest in Tonga, so as part of the theme, 'Tonga-a volcanic island', baking soda and vinegar were reacted. They also completed four 40-minute sessions on the crystallization of salt from brine as part of the same topic.

The Materials section of Workbook 1 was used in the context 'Tonga' in conjunction with the topic, 'Tapa Cloth' and simultaneously one suggested by the curriculum documents, 'Packaging'.

The teacher worked at three levels (LI, LII & LIII) in the classroom because of the age range (7 to 9 yrs). In this way parts of several physical science units were completed by the end of Term 3. Science was taught approximately 40 minutes per week. In Terms 1 and 2, Workbook 1 Activities 1-4 (pg 1-20) were completed on Materials.

Science taught by science topic set in the context of New Zealand

In contrast, the Workbooks were arranged by science topic - matter, light, forces, electricity, etc. not theme (Tonga, Packaging, etc.) Examples for these, i.e., the context, were drawn from Canterbury and New Zealand. The language, phraseology, and characters were purposely Kiwi as the respondents to the Book Survey had requested. Use of local references was intended to draw the students into the content and create familiarity and ownership which could extend to the content. However, it served to introduce the pupils to information about their own country as well.

Crystallization (Wbk 3, Activity 8), for example, fell under the concept of physical change (as opposed to chemical change) with new vocabulary such as: dissolves, substance, solution, etc., concepts such as: properties of matter, rate of dissolving,

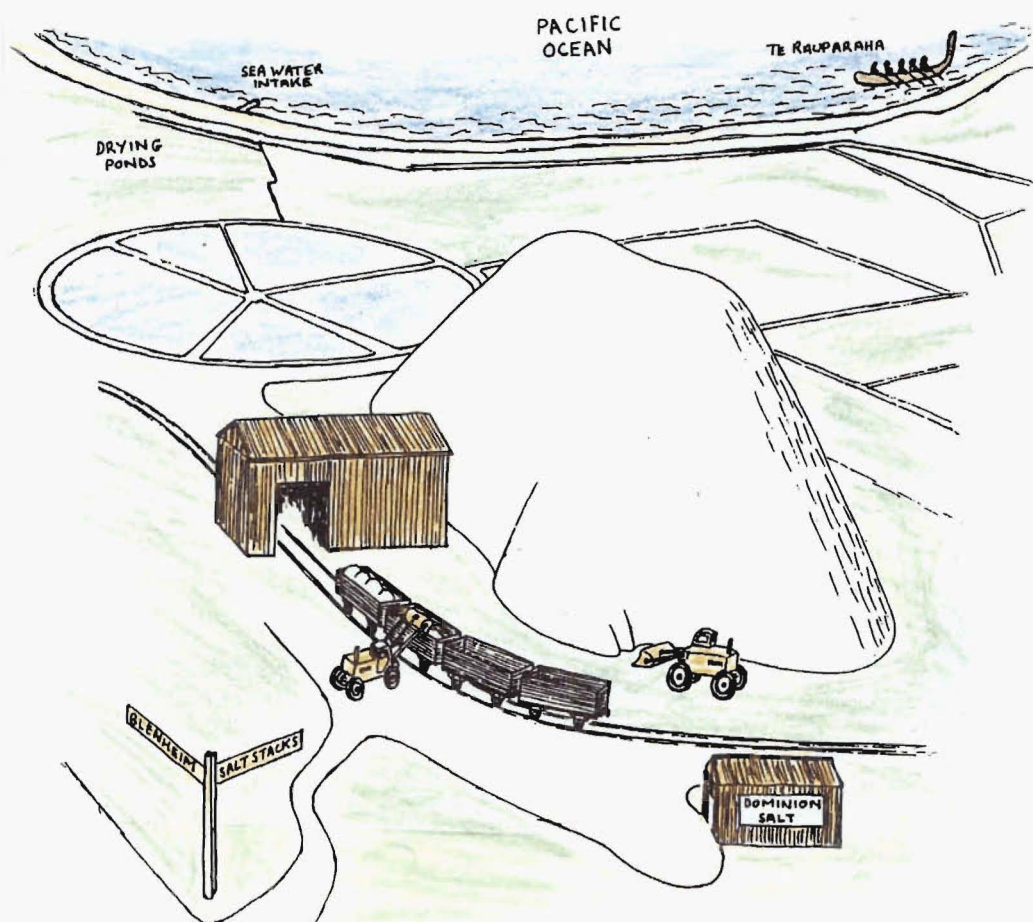
recognizing a solution, observing and recording an interaction causing a physical change, etc. An illustrative context was provided: Lake Grassmere Solar Salt works outside Blenheim. Also provided in the Teacher Guide was the contact address for their school information pack. Here is a sample page which a student has coloured in.

Do You Know?

Lake Grassmere contains a Solar Salt Works which was set up in 1943 to make salt. Seawater contains about 2.5% salt. During the summer months seawater is pumped into large ponds where the water is allowed to evaporate and the salt crystallizes on the bottom.

Lake Grassmere was chosen for this site because it is on Cook Strait, it is flat, it has the lowest rainfall of anywhere in New Zealand, and it has strong sunshine and dry north-westerly winds.

The large stacks of salt contain 100,000 tonnes of salt!

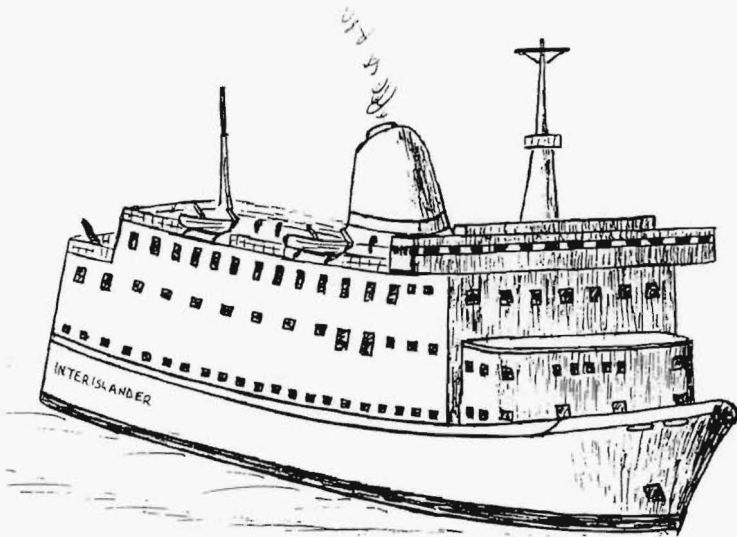


The ferry names are:

ARATIKA
'Straight Path'

ARAHURA
'Pathway to Dawn'

ARAHANGA
'The Bridge'



'Ara' in Maori means 'path'.

Can you guess the Maori word for...

'dawn'? Hura 'straight'? Tika 'to build'? hanga

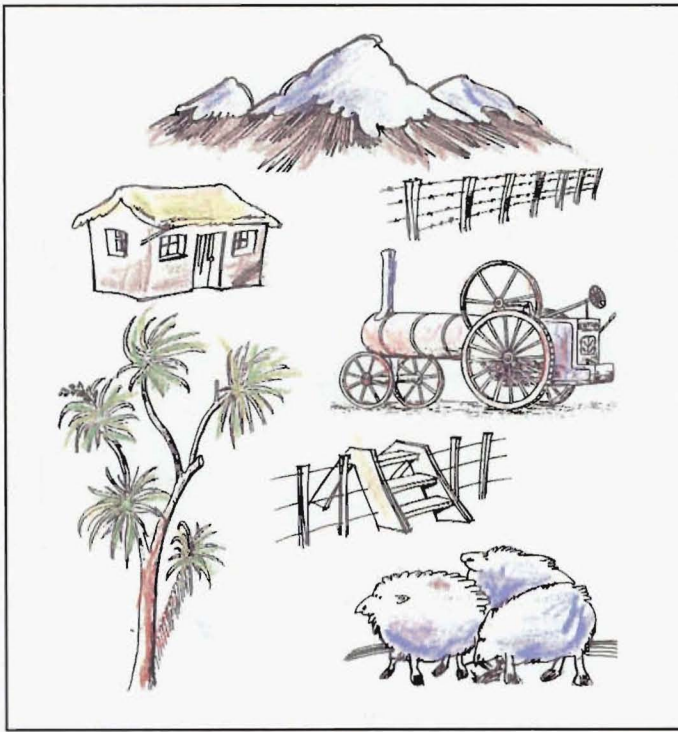
The Cook Strait ferries were used to illustrate the use of electromagnets. These are found throughout the ships to close doors automatically and so forth. The ferries also created a chance to introduce some Maori language terms.

Similarly, Magnus was drawn as a Kiwi bloke although the legend is about magnus lodos found by shepherds in Magnesia, a district in Thessaly.

One day, Magnus was looking after his sheep when suddenly he felt something pulling his iron hammer away from him. Then he saw that the iron nails in the soles of his gumboots were also starting to come out. What was happening?



Magnus later found out that he was standing next to a lodestone. A lodestone is a rock that contains a natural magnet. The lodestone attracted iron.



However, a North Island teacher commented,

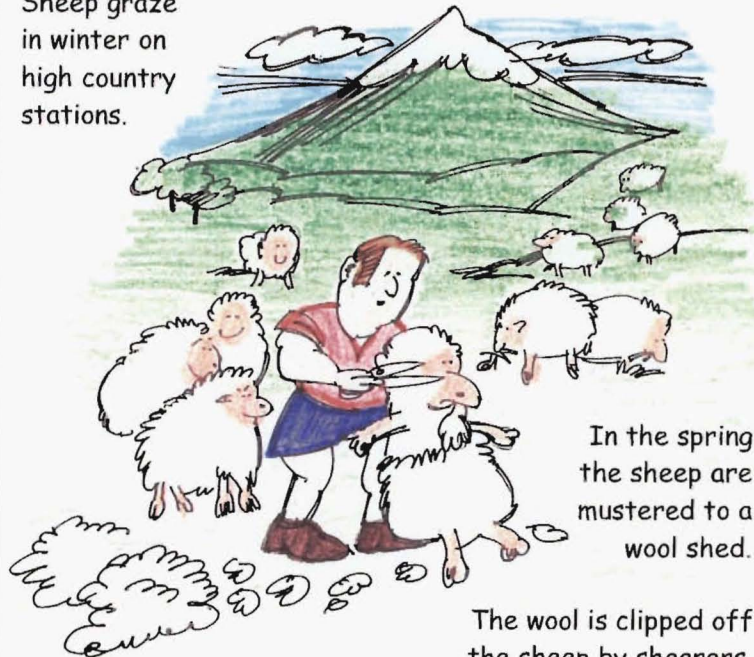
...the picture of the old (Canterbury Crofter's) cottage was completely foreign to the pupils as there are none built like this in the Waikato.

Materials were exemplified by 'wool', historically important, not only to New Zealand, but to England and the Commonwealth. The scene is familiar in the South Island, but less familiar to students in the North.

Do you know?

Sheep produce a material called *wool*.

Sheep graze in winter on high country stations.



In the spring the sheep are mustered to a wool shed.

The wool is clipped off the sheep by shearers.

The wool can be made into warm jerseys and blankets.



School 2: Year 0-8, Decile 3, 530 Pupils; Year 7/8, 30 Students, Median age 12

School 2 also started on 'Earth & Its Neighbors' because that topic fit the school science plan. They completed it in three lessons.

The students were very proud of their books.

They really enjoyed having a book—the illustrations for colouring were very good.

The context considered critical for learning involved a familiar south island scene, but unfortunately, the rail route across the Canterbury Plains has since been disbanded.

In the morning we see the sun rising in the east.

At noon the sun is overhead.

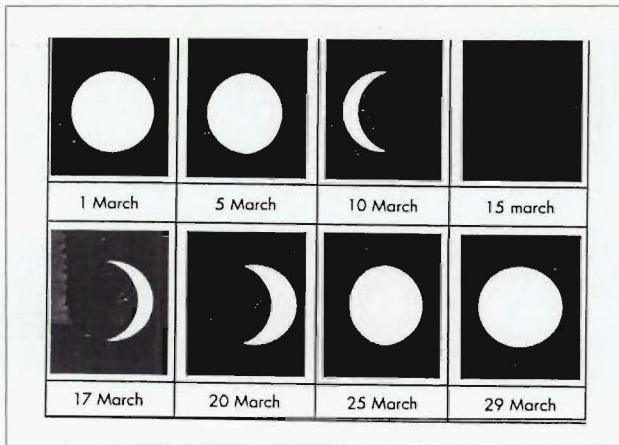
In the evening, we see it setting in the west.

Has the sun really moved across the sky? no



What has really happened?

It looks like it moved but the earth
was actually spinning. ✓



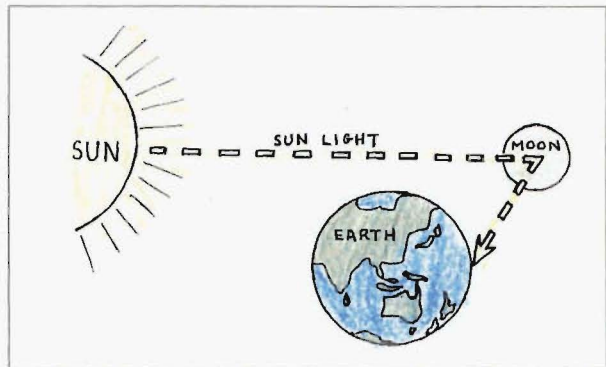
The children copied the blank moon chart from the Teacher's Guide into their own notebooks.

Then they used it as a diary for recording the shape of the moon each night over the term break.

A pupil wrote,

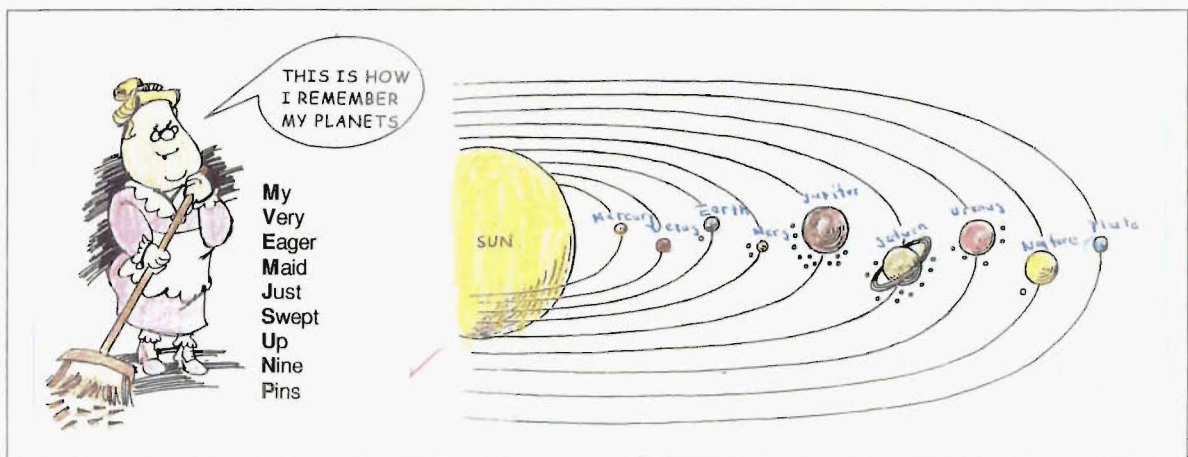
"What I liked best was... *the Moon Activity because we had to observe the moon for ten days and draw and colour it which was really fun. I also knew that it was the sunlight which gives the shading of the moon...this book helped me a lot for next year in high school.*

Thank you!



The workbooks showed that the children had an excellent grasp of satellites, orbital motion and phases of the moon. Another student wrote,

The most interesting part was knowing how to remember all planets by using other words like, "My very eager maid just swept up nine pins." I also enjoyed colouring in the pictures and answering the questions.



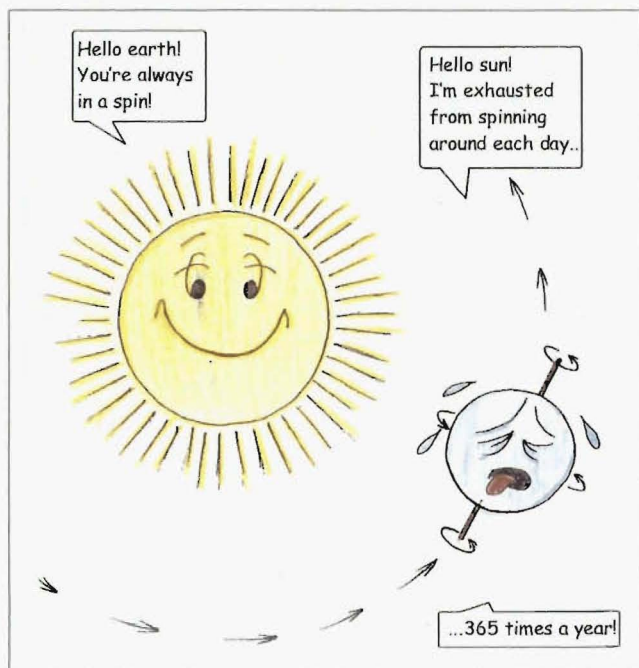
The teacher commented,

The pupils really enjoyed the activities.

It was easy for them to read, not too much information.

(The workbook) enabled them to be successful.

I was able to make them think back to last year's studies on Planet Earth.



Some pupils in this and other classes felt that the sun goes up in the day and the moon goes up at night.

Other explanations were very clear,

The earth spins around so that our side turns to the dark side while the sun just stays in its place.

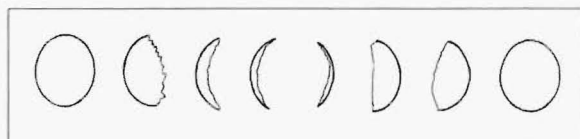
There were few misunderstandings: *One week after the full moon was a half moon because there was a tropical cyclone.*

How is it on the moon?

Its kind of weird, full of gravity.

Why did the shape of the moon change?

I think its from the climate or weather.



The children liked recording the shape of the moon each night at home...

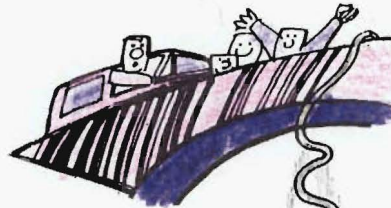
I really enjoyed doing the experiments on different materials, colouring in most of the pictures, getting to know more about our earth and the solar system, and also doing homework about the moon and watching day by day how it changes in shape. I think this book is amazing and I personally recommend this for all intermediate schools. Thanks.

The carpet and plastic desks were limitations.

All science has to be done in the classroom on a carpeted floor with plastic desks. This limits some types of experiments.

In Term 2 the class completed 'Materials' in six lessons.

The students showed a clear understanding of the concepts *materials* and *properties*.



The pupils worked well on task and cooperated well in groups.

They generated interesting questions

(about materials) and answers and

did the follow up

work in the

workbooks.



What properties would this material have?

It properties are that it has to stretchable and can retract the rider.

With regard to the plans in the Teacher Guide, the teacher wrote...

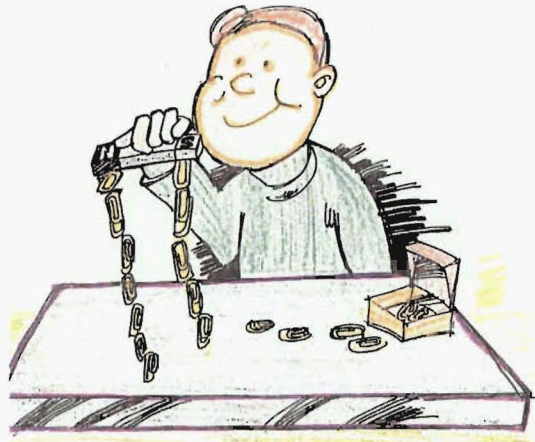
I really didn't need to write it all out but just follow your planning guide and then be flexible enough to guide the students to more discoveries.

In Term 3 the class completed Chapter 2, 'Magnets', working in large groups of eight.

The teacher wrote...

Pupils just loved working with magnets and used the equipment in a very sensible manner.

I supplemented with extra activities as our school has very good resources for magnets.



A student wrote...

I enjoyed learning all about magnets. There are some things that I didn't understand, but I never gave up and it's all worth it!! The information in the book helped me out with my science skills and I've done well!

The teacher thoughtfully provided colouring pencils for the pupils. Some of the colouring was of professional quality. Colouring could also help the pupils understand the activity.

A student commented,

What I liked best was doing experiments on magnets, colouring in pictures, and some of the important information given to students.

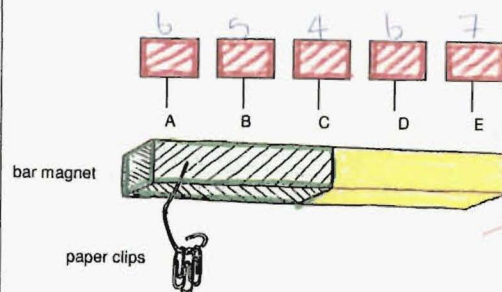
ACTIVITY 3 *Finding the poles of a bar magnet*

Use a paper clip to make a hook.

Hang the hook at part A of the magnet. Put paper clips one at a time on the hook until the hook drops off.

Repeat at places B, C, D, and E on the magnet.

Write the number of clips in the boxes below.



1. At which parts of the magnet could you hang the most paper clips?

on E & A

2. Which parts of the magnet had the strongest pull?

The ends of the magnets: A

3. Where are the poles of your bar magnet?

at either end of the magnet ☺

The teacher developed revision quizzes and reflected on this using action-research.

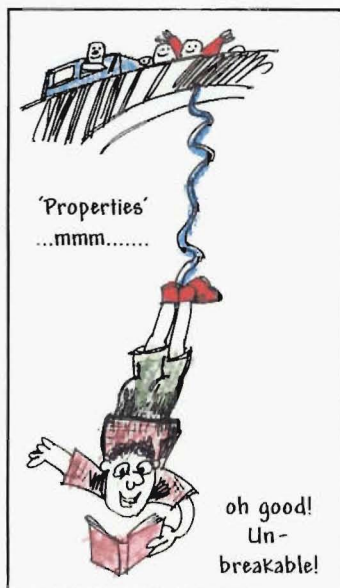
Aim: Revise work covered last year on gravity, planets, day and night.

Activity: A revision quiz which I made up.

Analysis: Using the quiz really focused the pupils into reading the Workbook to check up on what they knew. Considering this was the last day of term they stayed on task and enjoyed their activities. Hopefully, retention and understanding levels are good. Will try the quiz technique again.

The class had completed the physical science curriculum by early Term 3 and the whole science curriculum by the end of the year. The teacher wrote,

- *In the latter part of Term 3 we had a Musical Production which took over the timetable and Science did not get a look in.*
- *Term 4 was school camp and science was based on Marine Reserves, Farming, and Conservation related to Camp Studies.*
- *I thoroughly enjoyed the workbooks and found them to be a very supportive resource.*



The students appreciated the information and activities and were articulate and well-organized in their written comments. Some excerpts:

*I liked learning about **how different materials** like wood and clay are **used to build things** these days.*

*I liked **doing the experiments** and using different materials and getting to know science better.*

*I think the information **helped us a lot** for next year in high school.*

School 3: *Contributing Primary, Year 0-6, Decile 10, 620 Pupils; two classes*

1. Year 5/6, Age 9-10, 30 Students
2. Year 5/6, Ages 9 -11, 32 students

Two teachers and two classes used the same material, Workbook 1. Enough books were sent for each child to have one, but the teachers chose to double up and have one class use the first half and the other half use the 2nd half of the book. The reason may have been to conserve books and have some for the following year. It meant that the children had to leave their books at school so that the other class could use them, and they might not be able to take them home.

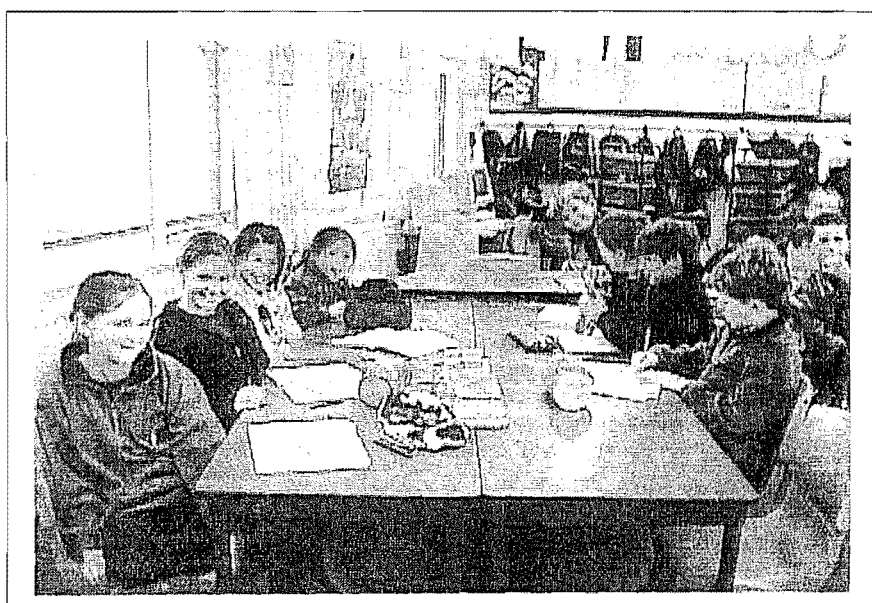
The first class worked through Chapter 1, Materials, Parts 1&2 in detail, meeting for Science 45 minutes per day, 4 days per week for two weeks in Term 1 on this topic.

The children were very enthusiastic about this unit.

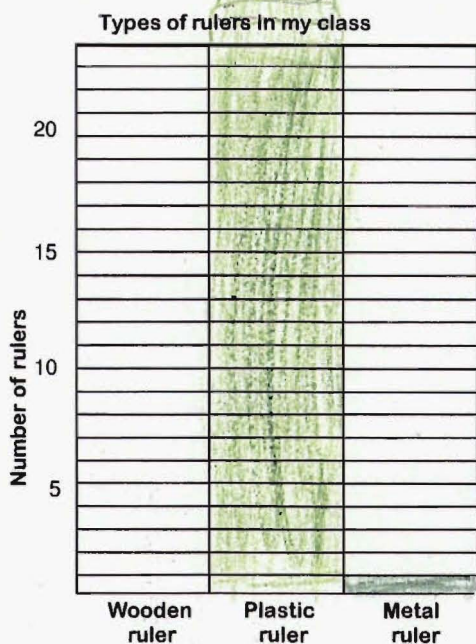
They enjoyed the format of having their own book and filling in answers, etc.

They found the experiments interesting and a change from working as a class to being in small groups.

There was opportunity for plenty of discussion and most children participated fully in this aspect.



2.(a) Draw a graph to show the result.



(b) What kind of ruler do most of the pupils have?

plastic.

The children found ways to adapt the graph form in the workbook to suit the abundance of plastic rulers.

The teacher wrote,

We have already done graphing in maths.

The children were able to give a variety of graphs, pie graphs, picture graphs, etc.

ACTIVITY 3 What are rulers made of?

1. Find out how many rulers in your class are made of wood, plastics or metal.

Write the numbers in the boxes below.



1

rulers in our class are made of wood....



20

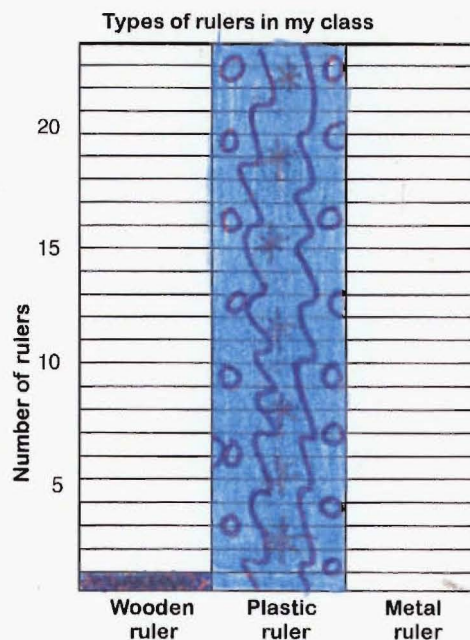
rulers are made of plastics...



0

rulers are made of metal.

2.(a) Draw a graph to show the result.

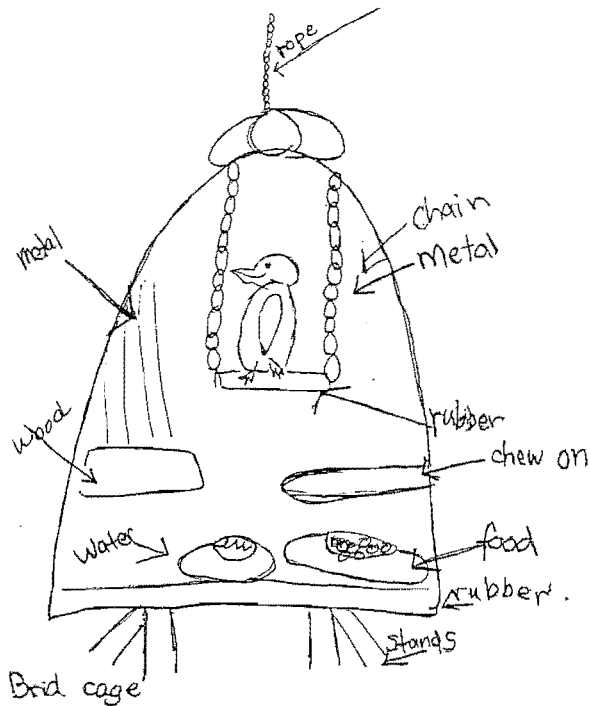


(b) What kind of ruler do most of the pupils have?

plastic

Pupil's drawing to illustrate materials.

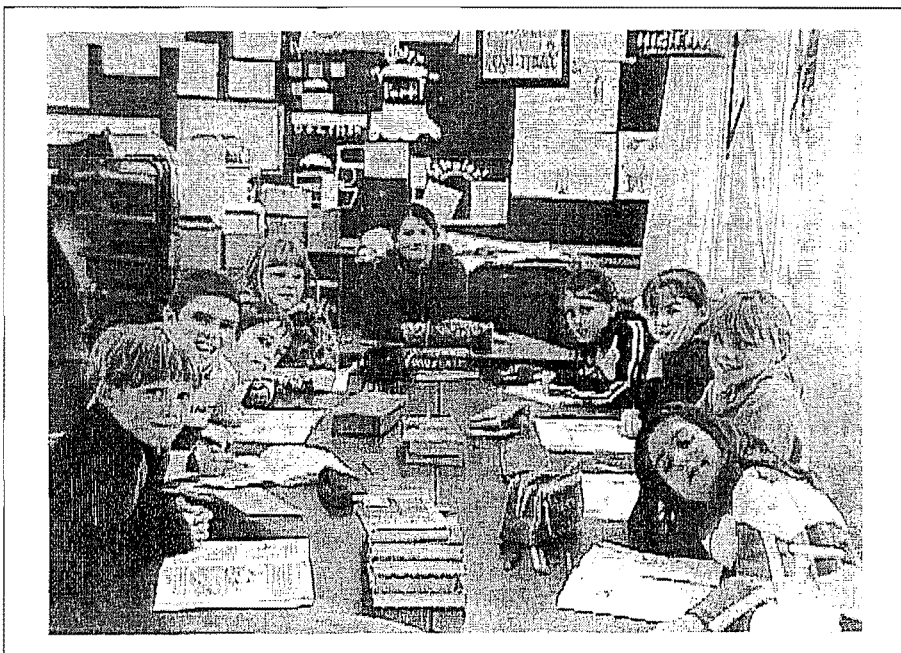
The teacher wrote,
The children liked
the idea of
designing their
own object.



The teacher wrote,
I know it was an
option, but I feel it
should be part of
the unit.

Rubber to get grip so it can get grip and won't
get hurt.
wood to stand on if something breaks
metal to make sure won't get out, so it
won't rust
rope because it needs to stay up so it won't
fall.

The teacher consolidated the concepts *materials* and *properties* and at the same time checked the understanding of the pupils by asking them to diagram their own ideas.



The teacher kept extensive notes. About the workbooks she wrote,

- *The children were very keen to start the lesson as they love having the booklets.*
- *The children were excited about having their own workbooks and enjoyed the idea of coloring in at this age level to show ownership.*

There were details about each lesson, for example, about Materials...

- *I collected a range of materials for the work on pg 7. Our collection of objects on the display table is growing gradually. Ruler, cup, towel, vase, balloon, ball, pen holder, peg, paintbrush, scissors, stapler, animal skin, leather, crayon. We classified these in two columns as on pg 8; we made a chart of properties of the materials and grouped them as 'good' and 'bad'. We discussed what these were made of and generated a discussion of objects around the room. We discussed our local rock, Hinuera Stone.*
- *Some children found it difficult to realize that one object like a blanket could be made of different materials like wool, nylon, cotton, without quite a bit of discussion and prompting. (After the 45 minute lesson..) Gauging by responses, most children are now able to identify materials and give some properties for each one. The table pg 19 provided lots of discussion about what they had at home and why different materials would be unsuitable for some objects. Some children still had difficulty explaining why, i.e. relating properties to the use of the material.*

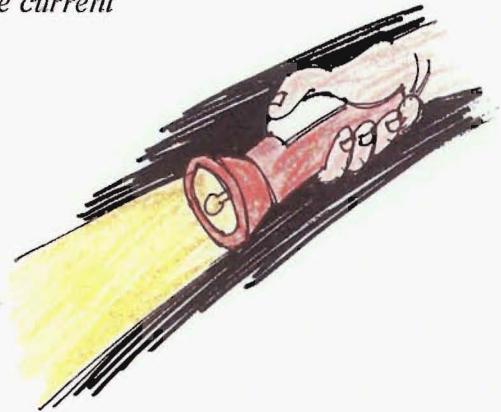
The children lived in the North Island and did not recognize...

- Oamaru limestone or the basaltic rocks in the Christchurch Cathedral
- the drawing of a Canterbury woolen cap
- that a spud carrier is a bag to carry potatoes ('spuds') which many families grow in their garden or along their driveway in Canterbury
- the old crofters hut or the antique farm tractor—common on Canterbury plains

The second class shared the same book with first class and worked out of the last half of it. The teacher noted before beginning...

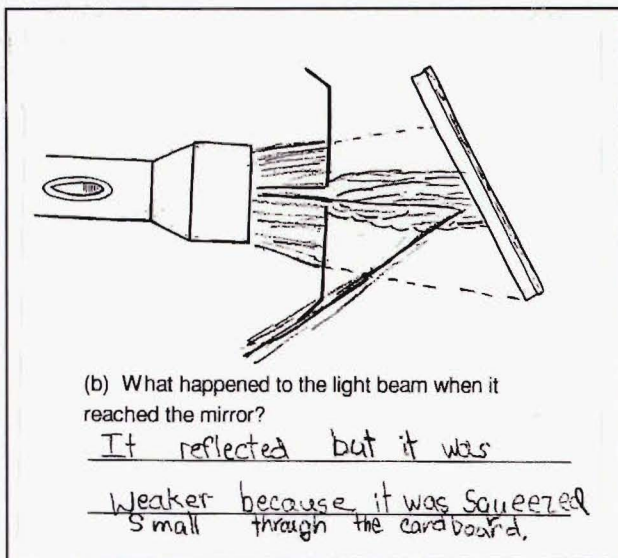
- *This material is easily set out for a teacher making it a breeze to plan lessons, organize any materials I might need, etc.*
- *Students are enthusiastic about having a workbook. They share their ideas easily.*
- *I have chosen the topic 'Light' to fit in with the current integrated theme based on 'Making Movies'.*

They completed this topic in two weeks, two hours per week, in Term 2. The students were able to bring their own torches to make light-box-type beams of light.



The students wrote,

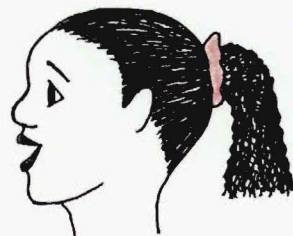
- *We liked the cartoons that were saying things to explain everything.*
- *I learned lots of things about shadows like when light rebounds off a mirror.*

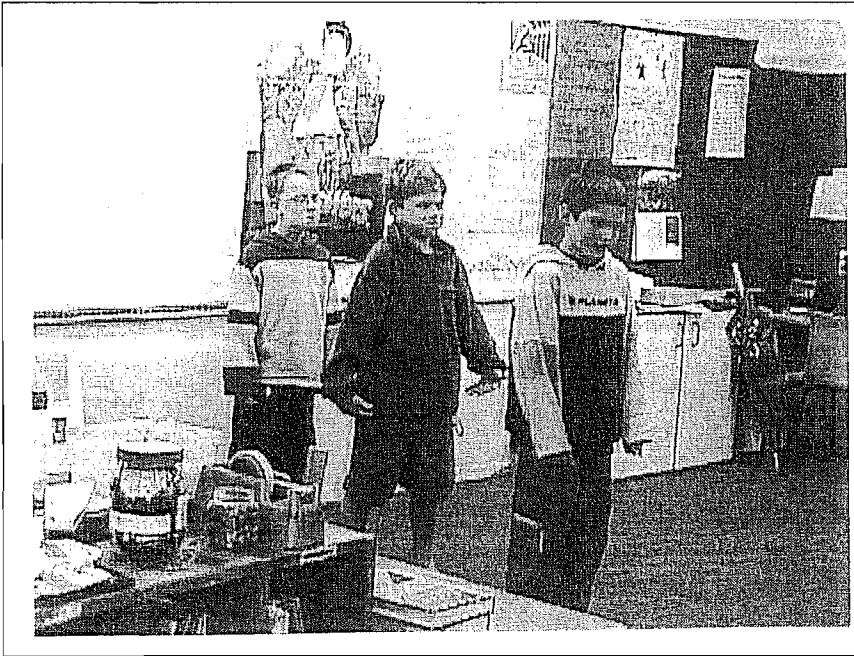


- *Not all objects let light through.*

- *Light can go through most clear and almost clear things.*

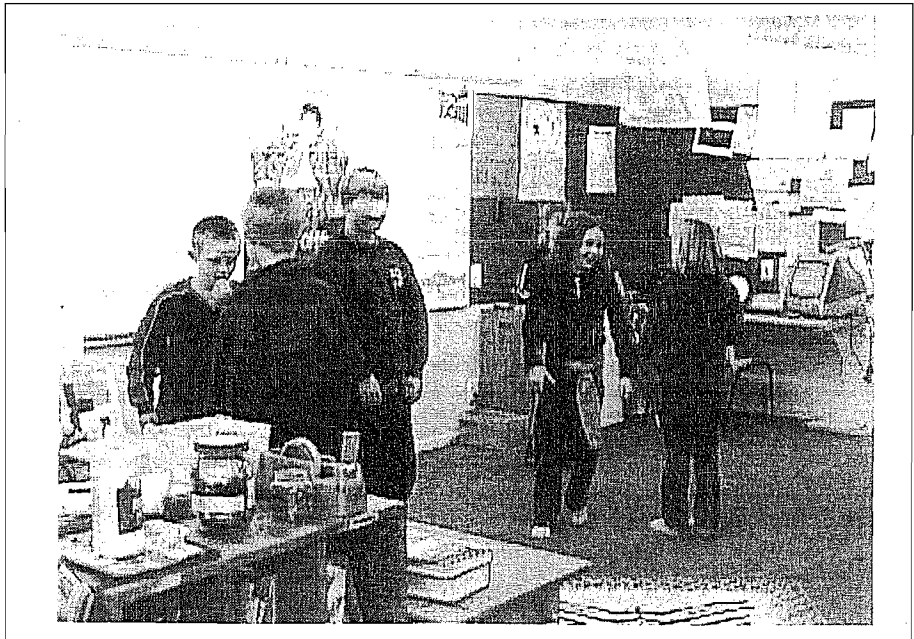
I SEE YOU !





They completed parts of Ch. 3, 'Earth & Its Neighbors' in three one-hour lessons during one week in Term 3. The pupils enjoyed acting out orbital motion.

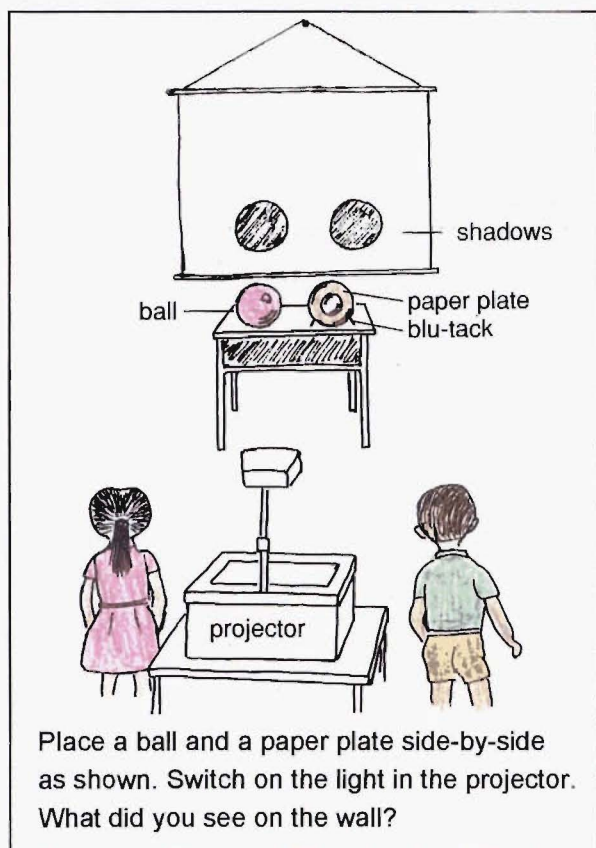
‣ *The students acted out how the sun, earth and moon move. They liked this sort of work and were interested to discuss the results with each other.*



The students wrote clear explanations.

- *The stars are just lots of suns but further away. Some of them are even bigger than the sun.*
- *You could see loads of stars at night but only one in daytime.*
- *It is dark at night because our part of the earth is not facing the sun.*
- *(During the day) the earth has spun around and orbited the sun a bit.*

Activity 5 is similar to one which comes up in university physics! The teacher wrote, *They experimented with the OHP. Unfortunately there was too much light in the room.*



Haliday & Resnick, 1997

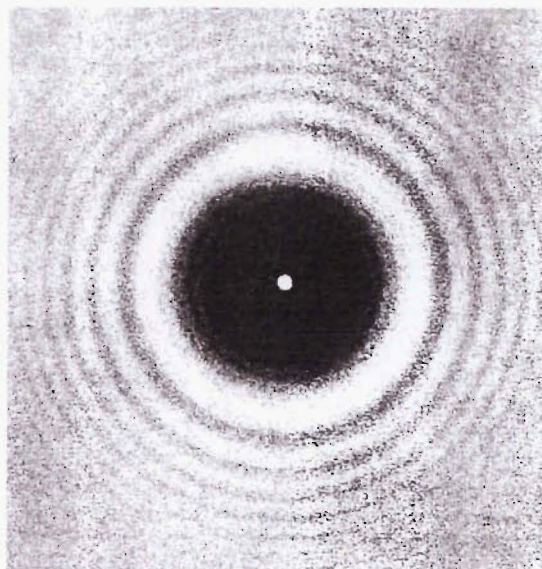
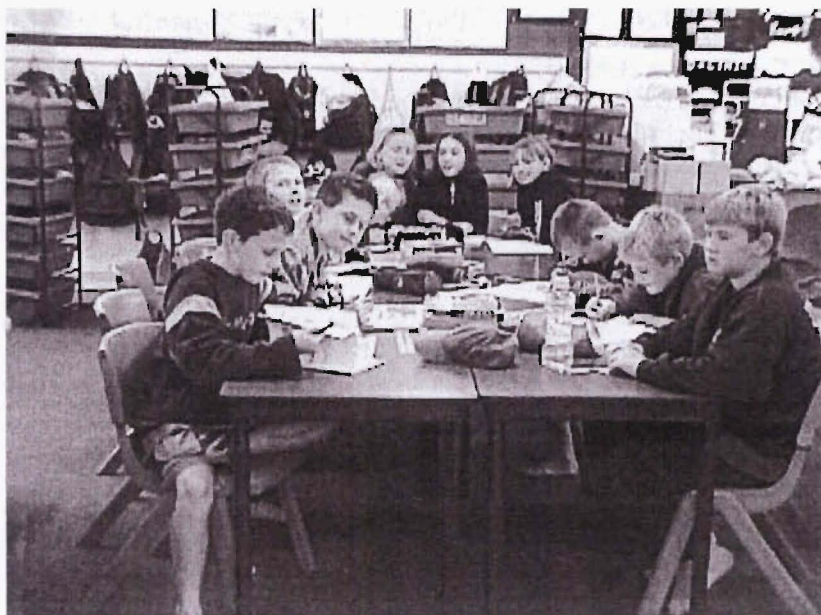
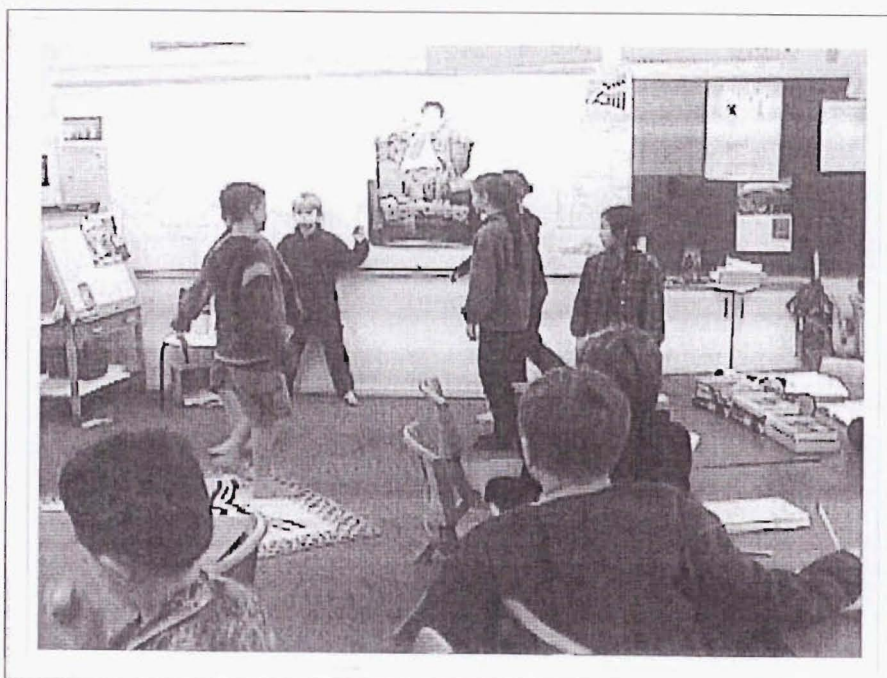


FIGURE 37-3 The diffraction pattern of a disk. Note the concentric diffraction rings and the Fresnel bright spot at the center of the pattern. This experiment is essentially identical to that arranged by the committee testing Fresnel's theories, because both the sphere they used and the disk used here have a cross section with a circular edge.

- *I liked the activity idea which stopped the students occasionally and asked them to reflect on their experiment, draw conclusions and so on. They then discussed a lot of what we had talked about and experimented with.*





This is an example of teachers who have taught the subject at the highest possible level, with painstaking care and great attention to detail and the learning needs of their pupils.

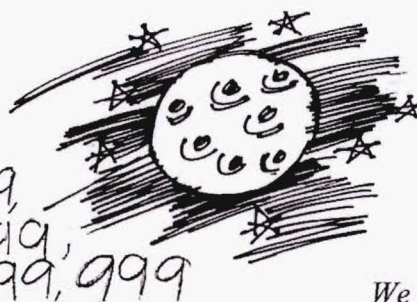
Not only have they taught it well, they have improvised on it and added to it and developed it as part of a greater school theme. They have enriched the reading/writing format by letting the children 'act out' planetary motion.



How many stars can you count in the night sky?

999999999999

999,999,999,999



From a student,
We liked the cartoons that were saying things to explain everything.

The teachers had the patience and tenacity to discuss new concepts and vocabulary such as materials and properties with the children and made sure they began to understand the meanings. The teachers have used their own local resources to make the subject not only interesting to the pupils, but something they are eager to try.

- *From a teaching point of view I found the information booklet very useful-background information, materials needed, some responses, teaching suggestions, and the final evaluation.*

Their personal skills and training are a far greater advantage than more science courses would be. They only need the appropriate resources to teach and they are away. As the second teacher commented,

- *This project (light) is easily set out for a teacher making it a breeze to plan lessons, organize any materials I might have, etc.*

They showed the children how to set up and use tables to organize data and classify objects, to think about, estimate and write down the numbers, to use specific vocabulary words and discuss their meaning, all the foundation tasks for science.

The only drawback was, as one of them wrote,

- *It is very difficult for them (the children) to discover things for themselves when the (lack of good) equipment makes it difficult to do it for the whole class.*

Since the workbook series was produced in 1998/9 several new written resources have become available. The workbooks filled an initial need and since then more material has come from a variety of other sources. Teachers now have an abundance of written resource material from which to choose. They still face the dilemma of putting together their own unit from the many resources available and to fit it into the theme or topic which the school is doing. Science advisors in some areas have prepared resource kits for hire and commercial kits are also now available for some topics. The teachers themselves are professionals of the highest caliber, doing an admirable job with what they've got for their students to work with.

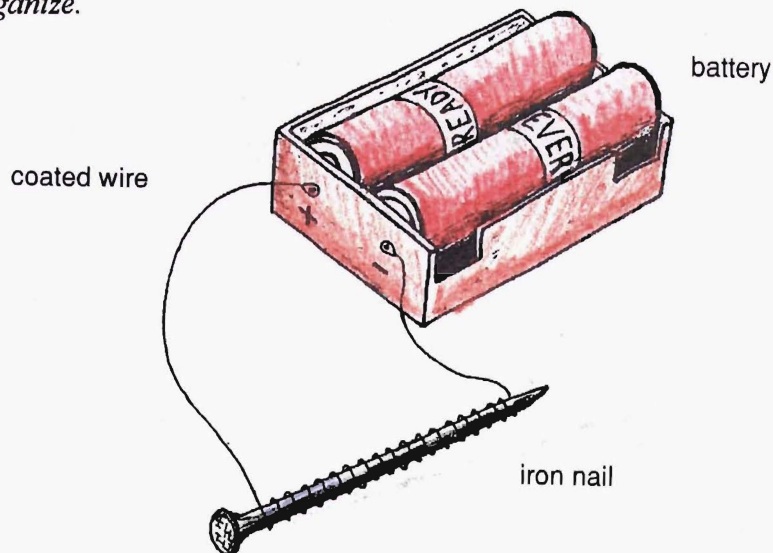
School 4: *Contributing Primary, Year 0-6, Decile 8, 380 Pupils, Yr 5, 9yrs, 32 Pupils*

This class worked hard—they did units on Magnets, Earth, Light, and Materials.

The teacher made excellent notes:

***Physical science is a challenge.** Little training, mine only to 4th Form and nothing at Teacher's College. It is inclined to be a male thing and I am not really interested in electricity, etc.*

However, I find my enthusiasm for teaching it has grown with the pupil enthusiasm, e.g., magnets is now great for me and the children and is easy to organize.



Too expensive to buy a battery for each child. Used one class demonstration model using a battery to magnetize a nail.

(a) What happened?

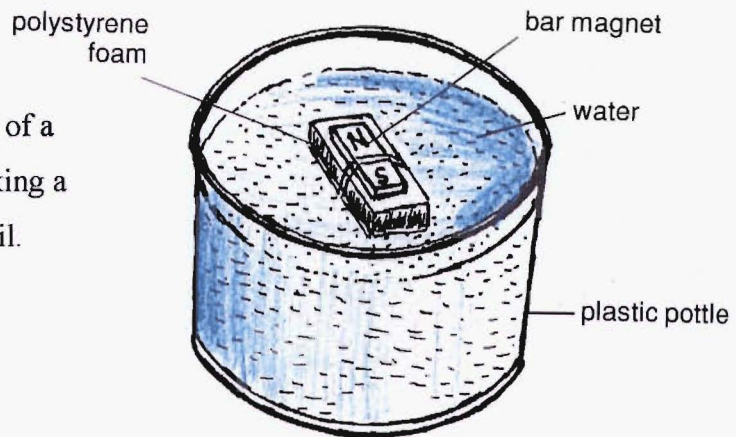
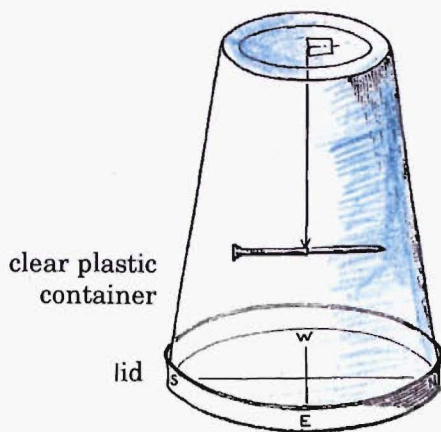
The nail picked up the
paper clip.

(b) Why?

Because the electricity
of the battery made the nail a
magnet.

- *Science is important but needs to be made practical and easy to teach and learn.*
- *The **books did give guidance** and information for the children and me.*
- *I did feel it **gave me guidelines** and pushed me into doing some activities I may not have covered otherwise.*

The pupils completed all the magnet experiments, including finding the direction of a freely-turning magnet and making a compass with a magnetized nail.



All the resources were gathered by the teacher: clear containers, magnets, string, nails, polystyrene, water, tape, paper clips, marbles, pins,...etc.

- *We have good book resources based on science in the school and also use the National Library service, but primary schools often do not have much equipment and teachers have to be innovative or buy their own.*
- *It is not a matter of going to the cupboard and taking what you need.*

Magnets vary in strength and some of the inexpensive ones are too weak for some activities. Being unable to get the experiments to work with weak magnets might have been frustrating for the pupils, but it did not deter them.

- *We couldn't get the paperclip to stay in the air, but the children tested the magnet to see if it still worked through the suggested materials.*
- *I let the children have a play with the magnets first as they were so excited just exploring. I had to push to get the planned activities done.*

Review Exercises were included in the Teacher Guides, but there were no tests per se with this material. In this case, the teacher found assessment material from another source and administered that as a further learning activity which covered the same concepts. She also gave a pre and post test with the following results:

Prior Knowledge	Later Brainstorming
Things stick to magnets	Magnets attract iron or steel.
Magnets are metal	Magnets are made of iron.
Magnets stick to other metals	Some materials don't stick to magnets.
Magnets can be different shapes, sizes colours.	Magnets can be different colours.
You can get fridge magnets.	Magnets are different shapes and sizes.
	A magnet has a north pole and a south pole.
	The north pole points north.
	If you put a north pole, with a north pole they will push away from each other.
	The north pole sticks to the south pole.
	If you make a magnet float, it will always point north/south.
	There are ring magnets and horseshoe magnets.
	You can make magnets by rubbing a magnet against a nail.
	Fridges have a long magnet on the door.
	Magnets are in a lot of things.
	Compasses use magnets.
	Magnets are useful.
	A south pole and a north pole will stick together.

One student's comments are shown here.

HOW DID YOU LIKE THE SCIENCE WORKBOOKS?

STUDENT OPINION SURVEY

First Name: Alexander Age: 9 School: _____

1. The Workbook(s) I used:

☒ Book 1

☐ Book 2

☐ Book 3

☐ Book 4

2. My rating of the book is: (circle) (low)

1

2

3

4

5

6

7

8


9

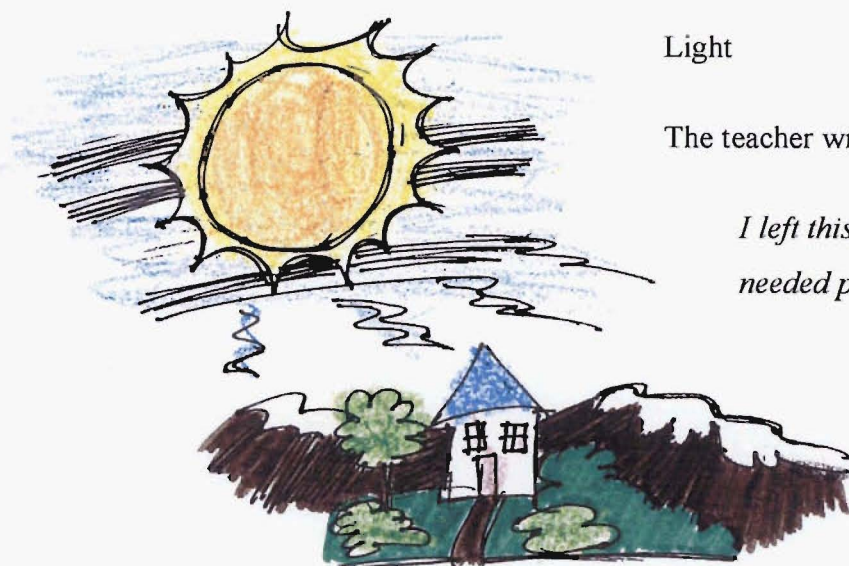
10 (great!)

3. My comments about it: e.g., "What I liked best was..."

doing the experiments on the
activities magnets

4. Thank you very much!





Light

The teacher wrote,

I left this unit to Term 4 as we needed plenty of sunlight.

*A beautiful day. Our sun dial activity worked well.
The children were constantly dashing out to check it.*

I set this (projector) up inside.

The pupils loved this.

Lots of gasps as the shadows changed shapes.

As it was a sunny day we also had shadow games outside, e.g. shadow tag.

The periscope was available all week for the children to use which they enjoyed. This free resource was much appreciated now and in the future.

Time of day	Length of shadow (cm)	Sketch of stick and shadow where it appeared.
9:30	56 cm	
10:30	37 cm	
11:30	25 cm	
12:30	8 cm	
1:30	16 cm	

2. Look at the results in the table.

(a) What happened to the length of the shadow at different times of the day?

It became smaller & smaller each hour.

(b) Why do you think this happened?

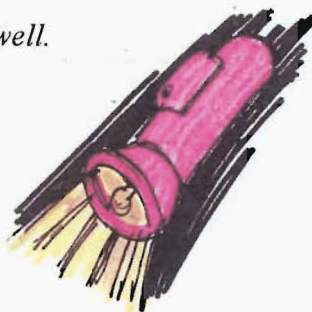
Because the sun was in different

(c) When was the longest shadow cast?

At 9:30

I liked it when we learnt about light because it told us about the sundial.

I set up one box and the children throughout the day observed and recorded their findings, then we came together to discuss it. We ‘brainstormed’ what the children knew about reflection, light sources, identifying light sources, the sun as a star, light for seeing, light for plant growth, light for Vitamin D.



A pupil wrote,
*I could not see
because there was no
light to bounce back
into my eyes.*

*With the torch I could see because
there was light in the box to bounce
back into my eyes.*

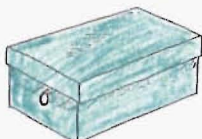
The teacher wrote,

I found the children's workbooks excellent for giving the pupils information at their level of understanding and reading age.

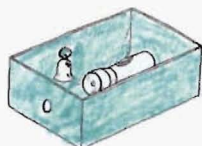
Primary schools are usually not well-resourced for science.

Therefore, not possible to have each child or even groups making a magnet using electricity activity and others in the book.

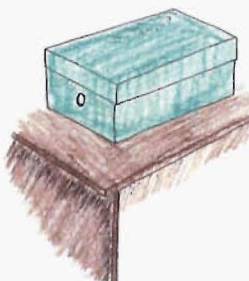
1. Cut a small hole in one end of a shoe box as shown.



- Put an unlighted torch and a small object in the box.

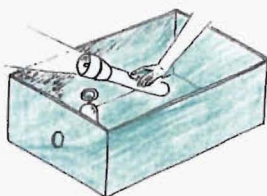


3. Cover the box and look through the hole.

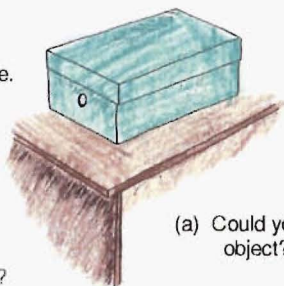


(a) Could you see the object inside the box?

4. Switch on the torch and cover the box again.



Now, look
through the hole.



(a) Could you see the object? ✓/e5

(b) Why ?

Science at this school was taught during ‘theme’ or ‘topic’ time which was 2½ afternoons, or approximately 2½ hours per week. Below is a typical weekly timetable.

	MON	TUES	WED	THUR	FRI
8:55	Admin, Fitness	Admin, Fitness	Admin, Fitness	Admin, Fitness	Admin, Fitness
9:10	Fitness	Choir	Fitness	Fitness	Fitness
9:15	English Oral, Written				
9:55	Reading	Reading	Reading	Reading	Library
10:25	Playtime	Swimming		Swimming	Swimming
10:45	Handwriting, Word Study	Handwriting, Word Study	Handwriting, Word Study	Handwriting, Word Study	Handwriting, Word Study
11:20	PE	PE	PE	Drama, Dance	Maths
11:40	Maths	Maths	Maths	Maths	Singing
12:30	Lunchtime				
1:25	Shared Story				
1:40	Topic	Topic	Art	Music/Sport	Topic/Assembly
2:55	Cleanup & Go				

The teacher continued,

- *Group work is integral to primary school, but there are always the leaders and the lookers on. It is up to the teacher to group carefully. Having their own book forced all children to participate.*
- *Recording in a book was fun for kids rather than on paper.*
- *The school is divided into three teams: Y1/2, Y3/4, Y5/6, so we have a two-year cyclic program.*
- *My class has 32 pupils. We are in a single cell, but all (5) classes plan together and run the same programs.*
- *At the end of each year the teachers organize next year classes considering the factors of good and bad pupil combinations and try to team each pupil with teachers we feel they will relate to.*
- *We cover the four strands in a year, so take a science unit once a term ranging from 2-4 weeks of the term.*
- *The science component would be taken in topic time which is three times per week= approximately 3 hours.*
- *We try as far as possible to plan holistically with all curriculum areas being covered, e.g., Fabric & Fibre: reading/writing, arts, technology were based on this.*

School 5: Private Year 7-10, Academic Group, Two Classes, Yr 7, Ages 10-12, 50 pupils

School 5 was a mixed gender private junior college belonging to the prestigious Academic Group of schools in NZ. These are known throughout the world for their high academic standards. Prince Edward attended one of them. In most cases there are long waiting lists for entrance which is competitive, dependent on intellectual ability. The base tuition fees start at over \$8,000 per year. The highest standard of education is expected by those who attend. The staff is of the highest quality and well paid. The schools are expected to achieve results and do so. Virtually 100% of the students eventually go on to attend University and attain jobs in white collar professions.

There were several important differences from the public schools system:

The school had an extensive science program and allocated 4½ hours per week to science every week all year at all levels.

- *On the whole we have more time allocated to science than most schools.*

The pupils were grouped in single year classes, Y7, Y8, Y9 or Y 10, on annual, not the two-year cycles found in public schools.

- *Pupils are on an annual timetable.*

Instead of being placed according to social relationships, the pupils were grouped into levels according to their math ability as demonstrated on a math pre-test.

- *Year levels are grouped according to their maths ability determined by a pre-test.*

In contrast to public schools, the pupils did not stay in the same classroom for each subject, but moved to a well-equipped laboratory for science.

- *As a private school we also have a much larger budget. From this we are able to purchase texts and equipment as we need it.*

The school had better equipment than what was suggested in the Workbooks. The teacher commented that the workbooks were,

- *Very useful, easy to use resource, especially if science equipment is limited.*

For example, the classes used ray boxes instead of flashlights for light ray activities. They had test tubes with stoppers and plastic tubing which they could use instead of the straw and plasticine setup suggested in the vinegar + baking soda experiment. They added extra activities as well, from additional resources or from the background knowledge of the teacher, a specialist science teacher.

Instead of being placed according to social relationships, the pupils were grouped into levels according to their math ability as demonstrated on a math pre-test.

- *Year levels are grouped according to their maths ability determined by a pre-test.*

One of the greatest differences from the public schools was that topics in science were covered by subject topic—not theme.

- *Topics in Science are covered by subject/topic.*

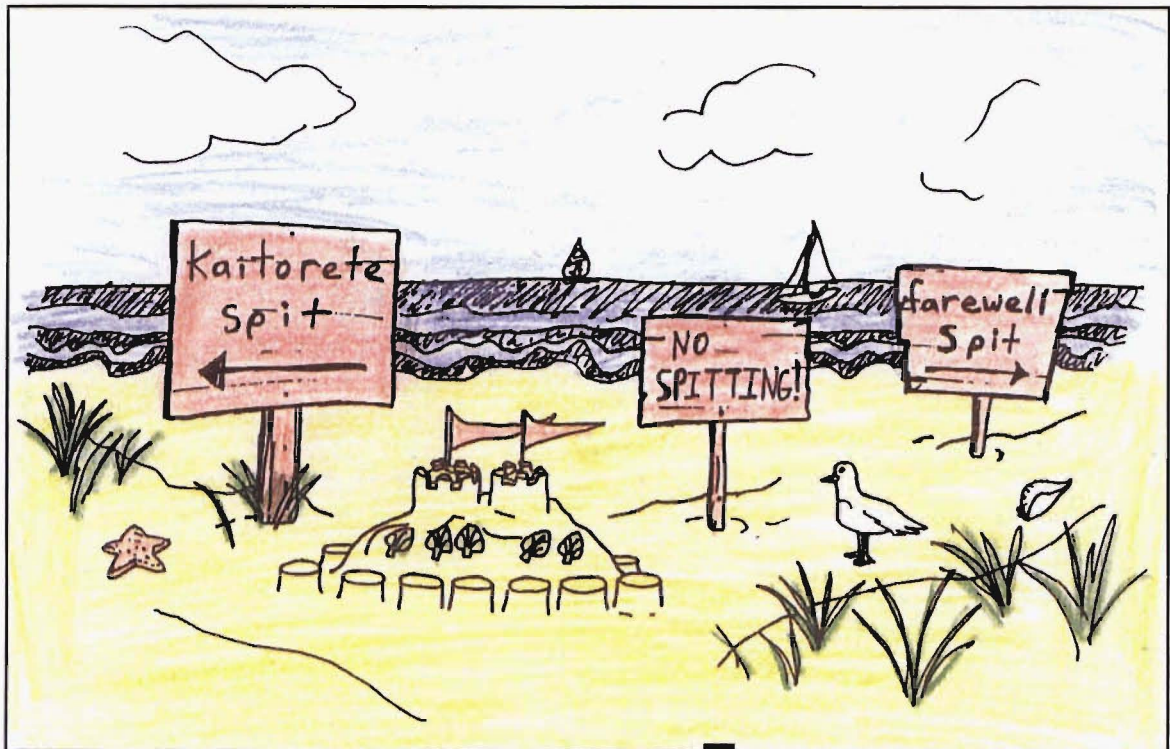
This was an important point for the teacher and she wrote more about it:

Theme vs. Subject approach

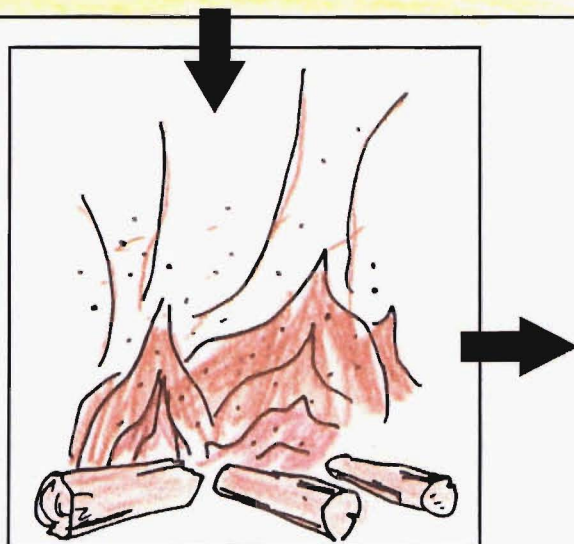
- *Sometimes in thematic approaches, especially with subject integration, many skills and concepts are not taught.*
- *With the topic approach it is easy to work through a progressing path. Also to build on understanding & knowledge in subsequent years.*

Hundreds of books were sent to the school since 60 (two class sets) of each book in the series had been requested. The pupils used the parts of Workbooks 1,2 and 3 which fit in with their purposes, but, unfortunately, only three Workbook 3 were returned for viewing. The students did some of the work on chemical and physical changes.

Glass is usually made from sand...



...mixed with other substances and heated to a very high temperature.



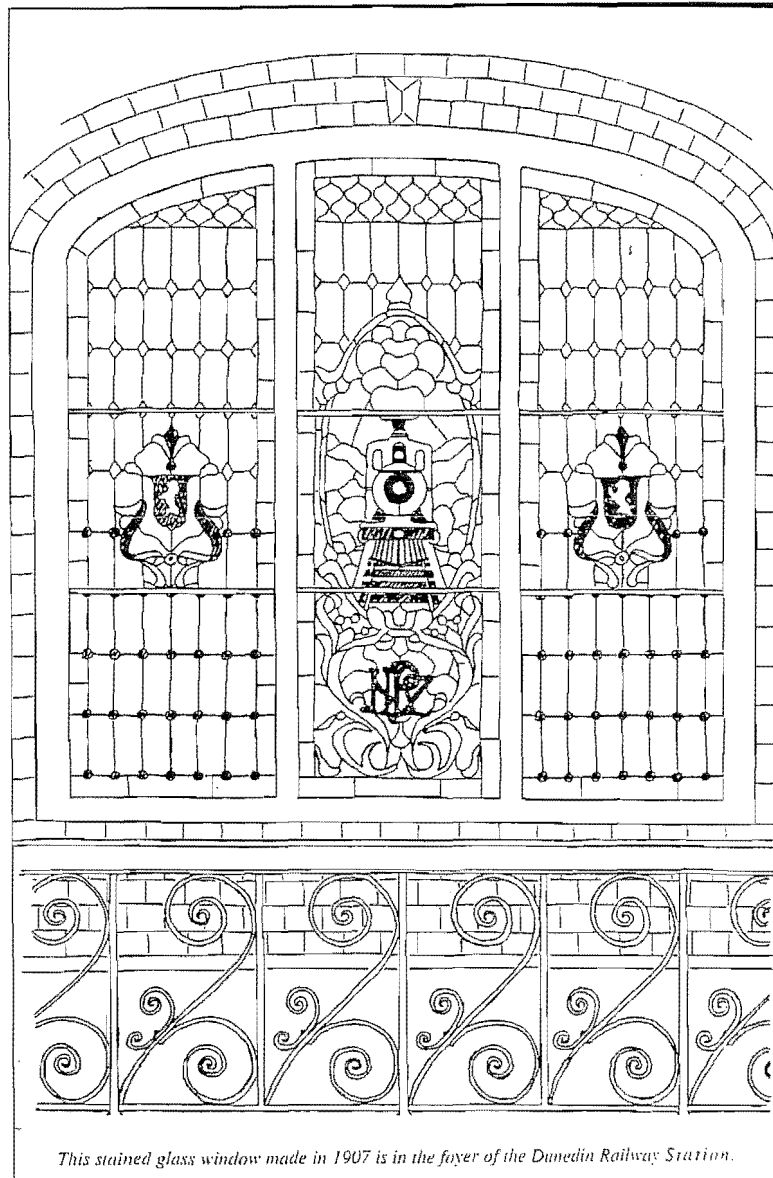
The mixture interacts with heat and changes into glass.

According to the teacher,

The workbook allowed some relief from photocopiable sheets, overheads or board work to copy.

The children seemed to agree,

I liked the fact that it was black and white so I could colour the book in and it was easy to write answers because we did not have to copy out the question.



I liked it because you don't have to write out all the activities because there is room to write results and answers.

I liked the books because you were able to colour in the pictures.

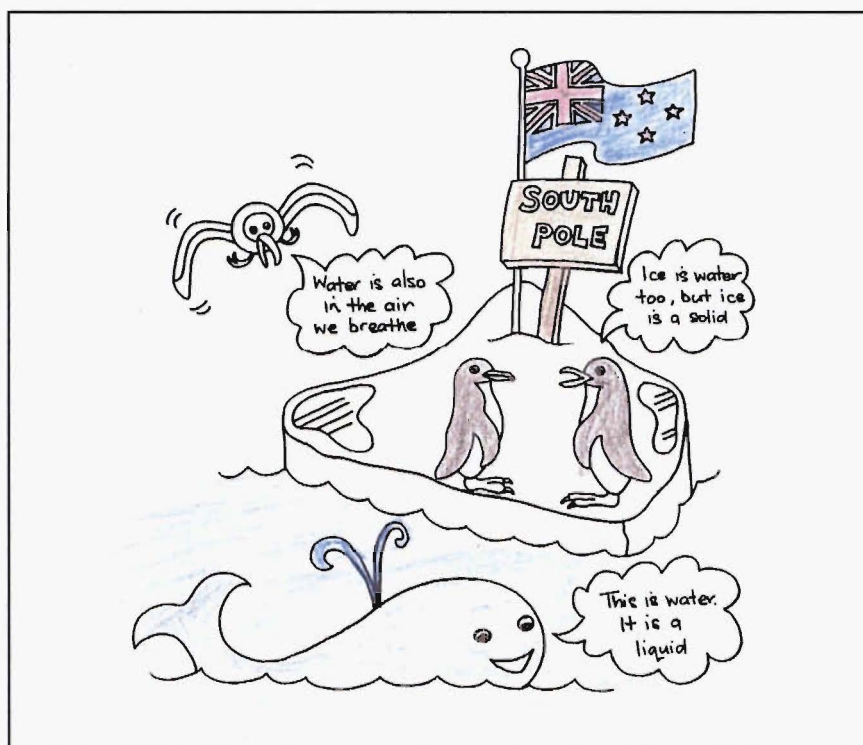
You didn't need to write full sentences, just answers.

Students did not gain anything from writing out questions or copying material from the board or from overhead projections, and in fact it might have slowed them down.

Saving time and keeping the students' focus and momentum on the activities at hand were hoped-for results of the workbook format, and it was encouraging to get such positive, un-prompted feedback confirming the time-saving aspect of the books.

They understood the activity from reading the instructions and looking at the pictures, and liked using the spaces provided to write answers and could give brief, one-word answers in many cases. In some cases, the pupils wanted more reading in-depth and more space to write longer answers.

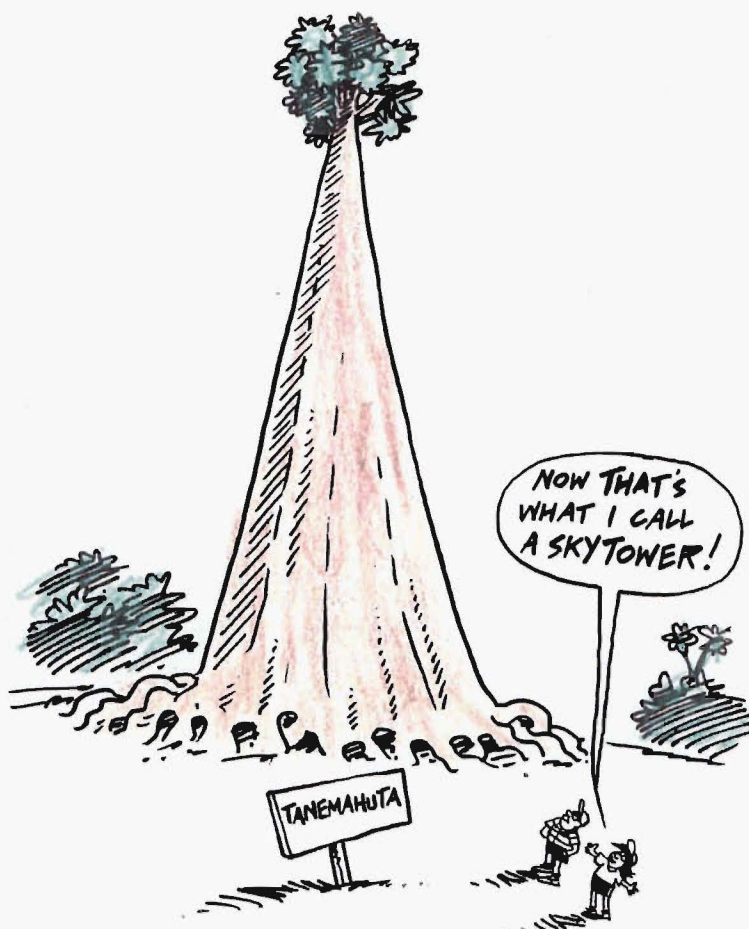
I liked the Science Workbook because it explained why it worked, how it worked, and how to do it.



It was a huge disappointment that out of about three hundred free books sent to the school on topics ranging from electricity and light to planet earth and materials only three single books were returned so further analysis and reporting could not be done.

Canterbury Homeschool Association

Several sets of books at all levels were provided upon request from the Canterbury Homeschool Association. Within the time limit of this study only one set was returned. In this case the family had to move several times during the year, so the caregiver was teacher. She completed Workbook 1 with her 8-year old child having no difficulty with the content. Many of the children in the Canterbury Association were advanced academically and the public school system could not accommodate their needs. In this study, only the private academic school allowed more able children to advance at their own academic speed, and private schools are financially out of reach for most students.



The action research showed the utility of the user-friendly guided student workbooks and teacher guides. Teachers with no prior science training in these subjects were able to teach the lessons as well or perhaps even better than someone who might have been trained in physical science. Considering their busy teaching schedules all the participants took a lot of time to give their insights and suggestions for teaching this new and unfamiliar curriculum area.

The material made for this project was quite different from what was available in the early and mid 1990's as shown in Figure 2.1, page 23. At that time the style of the books was new and the format untried. The teachers who were able to start teaching with them found they could teach the physical science curriculum and increased their teaching hours in the subject from what they had been in prior years. Teachers who could not start teaching did so for reasons beyond their control. All those who were able to complete some or all of one of the workbooks were favorable toward the material and expressed a feeling of mastery and enjoyment in teaching primary physical science once the books were in hand.

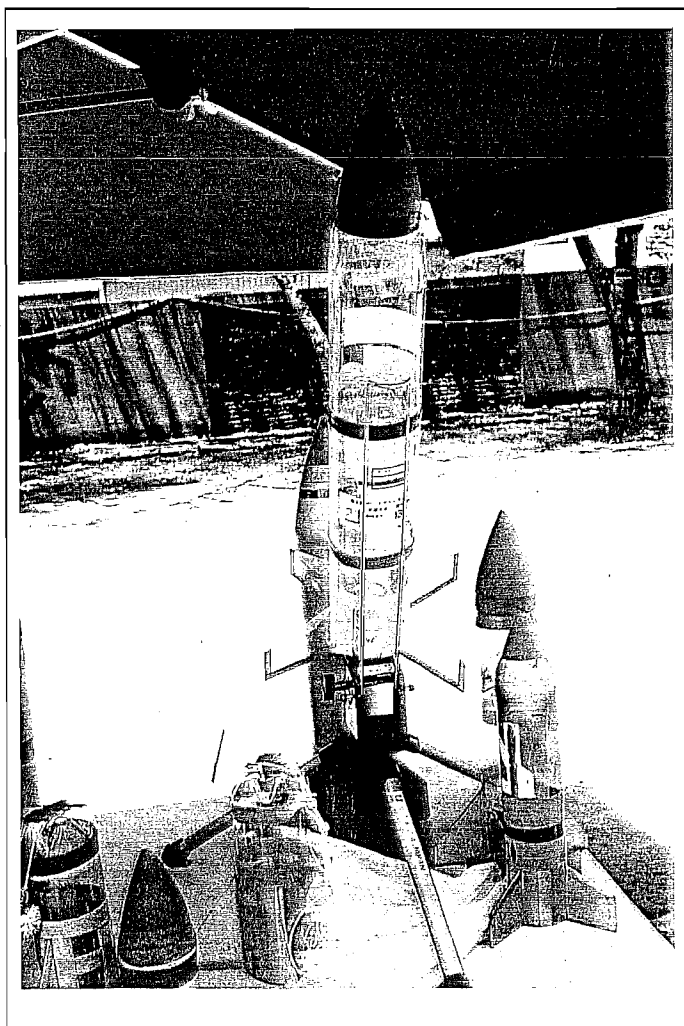
This chapter gives informal comparisons of our students to those in Singapore to get an indication as to whether potential is fulfilled or retarded in our late primary classes.

9.1 Getting Closer

As has been noted, after determining didactic criteria for workbooks from a literature search and after piloting workbooks with those criteria and then scouring the world for lessons for the final workbooks, material from Singapore was found to meet all the criteria so it was therefore decided to adapt that material for this study. This ensured an international standard of lessons. Those Singapore workbooks are now out of print and no longer available (Chng, 1981). However, the use of those lessons created an interest in informal comparisons with Singapore.

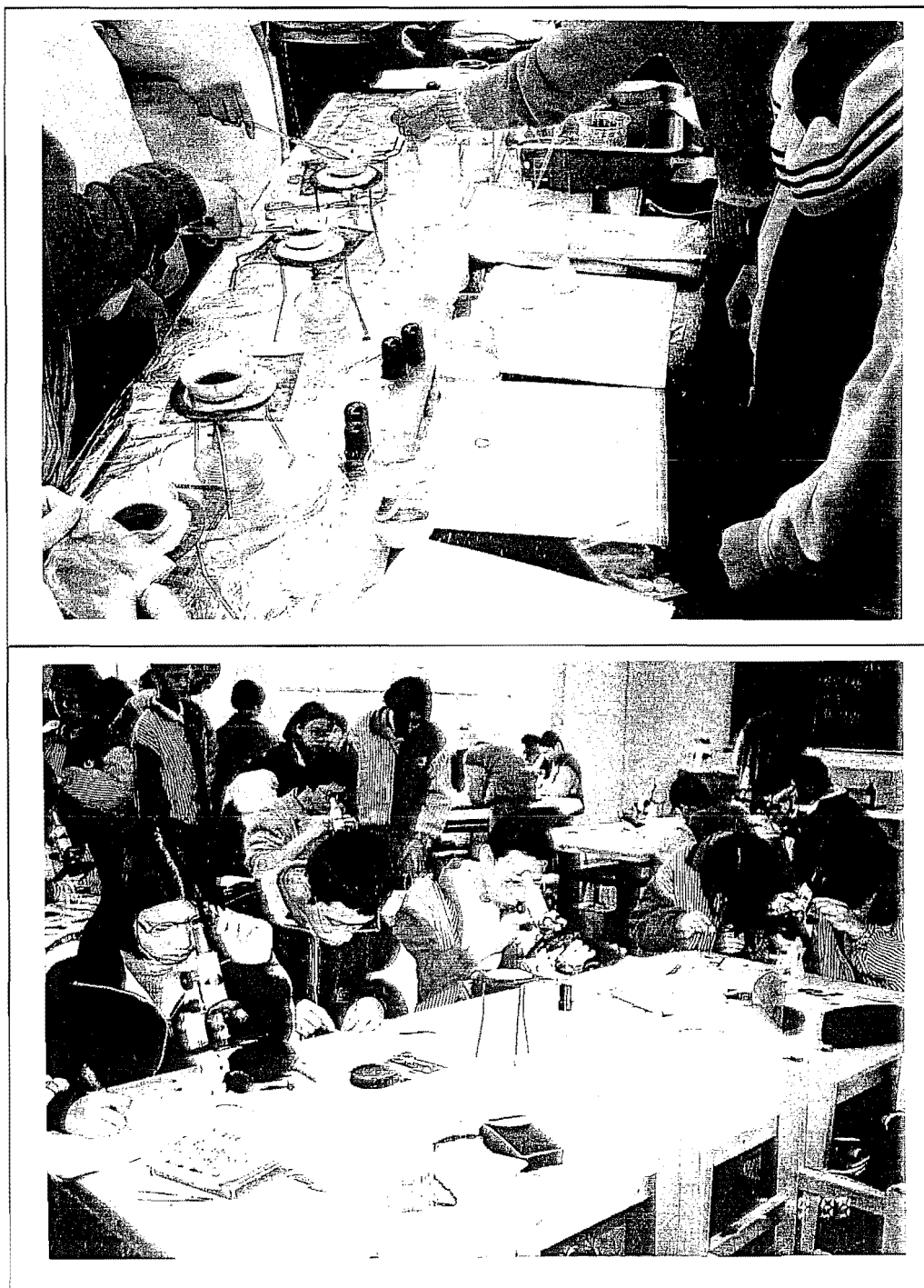
In this study workbooks were only used to show that teaching hours would increase if good material was at hand. It was not a comparative study and no comparisons were made with Singapore, but photos were requested. The only response was from Taipei, a country with similar didactics, which excels in math and science tests.

“Students provided dozens of water rockets in celebration of the school’s birthday.”



These photos show pupils doing lab activities. The photos would appear to be of students in Year 10 rather than students who are 10 years old, but are presented as they show a high level of discipline and concentration which must to some extent reflect pre-secondary training. The students appear well-equipped with crucibles, gauze pads, tongs, foil paper, clean absorbent mats, beakers, trays, shakers, bags of samples, and so forth. The caption read,

"Students, under their teacher's instruction, enjoyed themselves in learning by experiments." (Chen, 2002)



9.2 Not there yet

The material produced was adapted from that used in Singapore, but, except for the private school, the public schools in this study attempted far less of the material than would have been covered in Singapore. All but one teacher in the action research study chose to use only Workbook 1 and the most common topics covered were Materials, Light, and Earth and its Neighbors. One of the schools in the Early Book Trials used Workbook 2 covering Electricity but the author had to supply all the equipment (over \$500). The private school mostly used Workbook 3, but also augmented with other material. Only one school completed all of Workbook 1 and most chose only a few activities, sometimes as little as a few pages. No school in either study attempted the activities on levers and pulleys or forces.

The teachers tried the new activities and observed how they went, how much time they took, what questions to anticipate, and so forth. Much of what was accomplished depended on having equipment and space. The teachers did not want to put together these specialty lessons after being trained as generalists, but could deliver the lessons prepared by specialists.

Each primary public school in Singapore follows the lesson plan set by the Ministry of Education. The high streams and the low streams follow slightly different lesson, but all schools cover the same material. In NZ there is a wide range of lesson plans and the same material is not used from school to school. Children may eventually enter the same secondary class with quite different primary preparation.

The population size of Singapore is similar to that of New Zealand but the land space is less than that of Lake Taupo. There are relatively few primary schools, about 200 compared with over 2,000 in New Zealand. The schools are much larger, having about 2,000 pupils each, and are run in shifts, a.m. (7—1) and p.m. (12:30—6:30) with a joint assembly at midday. Economies of scale are to their advantage.

The curriculum in Singapore is basic: language, science, math and social studies, although more time for creative classes in drama and the arts is being introduced. The children are tested on the core topics at the end of each year and placed in streams based on math and language ability. At the end of primary school the children are again tested, this time for placement and streaming in secondary school—technical or academic.

In contrast, this study found a wide difference between schools in New Zealand as to what is taught, although every school in its own way meets the national curriculum guidelines. For example, two teachers in this study indicated that their classes had completed a unit on ‘Sound’. One had no space, facilities nor equipment other than a sea shell and the children put this to their ear. The other had a lab, a specialist science teacher, tuning forks, slinkies, computers, stop-clocks, reference books, videos, a variety of worksheets, etc., and spent three weeks at 4½ hours per week on ‘Sound’- timing sound waves, understanding the Doppler effect, looking at oscilloscope signals for various pleasant and unpleasant sounds, learning about waves, vibrations, frequency, pitch, compressed air, shock waves, sonic booms, Mach 1 and greater, detecting sound, sound technology, ears, hearing, etc, etc. Both schools had the same *intended* curriculum but the *implemented* curriculum was quite different. The *attained* curriculum was also probably quite different.

The total number of hours per day in class in Singapore is the same as in New Zealand, but because of the split at midday in Singapore, all students essentially have a half day free, either the morning or the afternoon. They may use the free block of time for activities such as music, sport, other training, skills and homework, which in NZ may be squeezed into the regular curriculum.

Good lessons, time, enthusiastic pupils and well-trained teachers add up to only part of the story. As exemplified by the East Coast full primary in our study which had a trained science teacher with 30 years experience, good books, willing students and great intentions, the cost of gearing up was prohibitive. The economies of scale were not there, and a logical decision was made to cover other

parts of the curriculum instead. The under-teaching which persists is due in part to a lack of supplies, facilities and space. Other factors found included the grouping of children in wide, 2- and 3-year age ranges, teaching to a theme, overcrowded curriculum, lack of supporting material such as videos, books, etc., open plan classrooms and competition from free resource packs on other topics. The private middle school was well-equipped, placed greater emphasis on science than did the public schools, and organized lessons by science topic and related methods rather than by themes.

Since the 1960's nations have initiated reforms in primary education such as the creation of junior (year 0-6), middle (year 7-9) and senior (year 10-13) year groupings. Children in middle school are old enough to move from room to room and from specialist teacher to specialist teacher. An intermediate allows teachers to specialize in subject areas, and makes it cost-effective to have laboratories and equipment. This grouping was similar to that in the private academic school in this study. It was not used in the public schools. Most public systems still go from full eight year primary (year 0-8) to a five-year secondary (year 9-13). Currently there are 2,300 primaries and 142 (year 7-8) intermediates.

The comments from teachers in this study indicated that individual student workbooks guided learning, saved time from copying off the board, and helped bring out the work of the individuals within the groups. Teachers indicated that teacher guides with information, lesson plans, learning outcomes, vocabulary lists, review exercises and so forth made teaching these subjects 'a breeze'.

This workbooks made for this study were adapted from material used in Singapore where all children would have completed all of the material in Books 1, 2, 3 and 4 at ages 9, 10, 11 and 12 respectively. In this study most schools only used Book 1 for ages 9, 10, 11 or 12 and from this it could be inferred that the NZ classrooms are not working at as high a level as those in Singapore in this subject. This is a generalization only because there are many variables and differences unaccounted for. However, it is an observation that should be stated.

10.1 Summary, contribution and implications of this study

In 1996 we set out to show that primary teachers could deliver the new physical science curriculum of 1993 with no further training if they had the right books. We searched the literature for didactics which positively impact learning so that those ideas could be incorporated into any books we would make.

We commenced with a Pilot Project about density. We found the class room was not suitable for lab activities, there was no equipment, we had to shove the desks aside and crawl around the floor because there was no suitable bench. It was nearly impossible to implement the new curriculum. The students liked the guided workbooks but, except for our project, they had never done active physical science and would not do any until they went to secondary school.

We conducted a Book Survey which confirmed a lack of resource material available in New Zealand for teaching the subject at that time. We simultaneously scoured resources from many countries in Europe, Asia and North America. We found that the material from Singapore exactly matched the criteria we had previously deduced as best practice, as gleaned from the literature search. It thus matched what we proposed to make. It was noteworthy that Singapore was also the top scoring country on international tests for those ages. The Singapore books are now out of print. It was decided to adapt the style and material of the Singaporean schoolbooks for this study.

We then produced Materials—about 12,000 guided workbooks for each of the last four pre-secondary years, i.e., 3000 for age nine, 3000 for age ten, 3000 for age eleven and 3000 for age twelve. As the books became available several hundreds of teachers at full and contributing primary, intermediate, secondary, Te Kura Kaupapa, area, private, religious, special needs, and home schools, juvenile homes,

hospitals etc. purchased the books as desk reference sets from which they could photocopy lessons, or as class sets so their pupils could each have a book. These people benefited from the study but were not part of it. As with any book, merely getting the book did not imply wanting to become part of a study or be put on a mailing list. Very few teachers wanted to be part of a study.

About 12 teachers volunteered to use the books and answer questionnaires after a term or two. This was the Early Trials Questionnaire.

About 12 teachers volunteered to keep journals while teaching physical science using any material. This was the Action Research Group.

About 85 teachers responded to a Resources Survey. It had become clear that there were several confounding factors in teaching primary physical science. At first it was important to produce books so that guiding material was available. Then problems such as equipment, facilities, classrooms architecture, classroom organization, time, prioritization, etc. became apparent and were recorded in this study, but these problems could only be addressed by individual schools. Kits circulated from one school to the next could remedy some of the problems.

Several serious, complex problems were identified with respect to teaching primary physical science. It would appear from this study that educational opportunities in the physical sciences are limited and not equal despite the existence of good books. New Zealand has a history of elitism in education. Until 1936 many children were excluded from high school by the Primary School Proficiency Certificate at age 12. A predetermined failure rate of 40% ensured that nearly half the population had only a primary education. It was only abolished when the Labour government got into power. Unfortunately, it was replaced by a School Cert exam at age 15 with the discriminatory requirement that English must be one of the subjects tested and that half the students must fail. As late as the 1970's when free public education to age 18 was available in most advanced societies, New Zealand had a cull rate that took out all but about 10%. The knock-on effects of these practices on the current state of facilities, teacher education, student and parent expectations, and so forth for intermediate years are still evident today.

This study included a school in the East Coast –a full primary to age 12—without enough equipment to start Book 1. A school in South Auckland appeared trying to implement the curriculum despite having no equipment, space or facilities. The problems persist and need to be redressed.

The new curriculum was published in 1993 and in 1996 an ERO report blamed teachers for not implementing the physical science portion of it. It was shown by this study that a teacher with no background in physics or chemistry could teach primary physical science at an international standard once good books were in hand as long as equipment, space and facilities were not obstacles. The ERO report did not mention the need for books, buildings, space, equipment, and everything else required for teaching primary physical science.

The study was carried out in a naturalistic uncontrolled setting. We were surprised to find the teachers and students so enthusiastic about the subject which had been considered dull or difficult. The teachers themselves expressed their surprise at enjoying the subject so much once the good books were in hand.

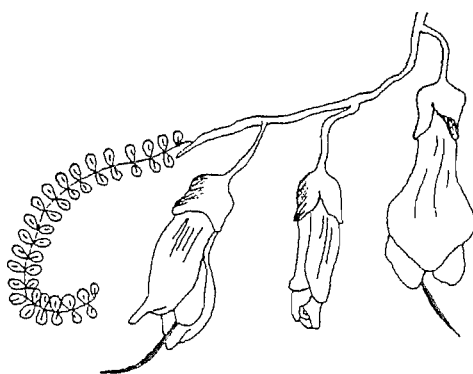
This study redressed a major problem of that time— dearth of teaching material. There are other issues that should be followed up. In this study about half of the volunteers could not start teaching physical science because they lacked equipment or for other reasons. It could be inferred that physical science cannot be taught at the primary level in every full primary school. New Zealand is a country where primary school may extend to age 12. The infrastructure that is built into intermediate schools to accommodate the greater needs and abilities of older students may therefore be underdeveloped. In intermediate or secondary school one lab is stocked and different classes of students circulate in and out each hour. In primary school students usually stay in the same room all day and it is not economically feasible to stock one room for one class with equipment used only a few lessons in the year. There are currently about 2003 full and contributing primaries and 127 separate intermediates (Min. of Ed., 2003).

Given the limitations of this study and that the findings are only indicators, some of the achievements, and outcomes are:

- The project had many letters of support and a \$60,000 grant for education.
- 12,000 student workbooks of international standard and quality, 3000 for each of the last four pre-secondary school years were published and distributed. The workbooks were adapted from material used in Singapore in 1997/8 and this material has now in 2004 been out of print for several years.
- Equipment for all the activities was made or purchased and all activities were tested. Suppliers in NZ for the equipment were listed for every activity.
- Pupil enthusiasm about learning physical science was high.
- Pupil enthusiasm about having workbooks was high.
- Teacher interest is driven at least in part by pupil enthusiasm and not necessarily by the teacher's subject knowledge or lack thereof.
- There is under-teaching of physical science in the four pre-secondary years.
- There was anecdotal evidence that the schools in the study did not work in a consistent pattern over four years to cover the foundation work in physical science that was covered in Singapore and that the NZ schools worked a few years behind those in Singapore.
- Many classrooms lack proper equipment and supplies, space, and facilities.
- Primary physical science may have been added to the curriculum without adequate appreciation of the costs and practical logistics of teaching it. No mention of these issues was made in the ERO report of the 1996.
- The student workbooks and teacher guides enabled the teaching of physical science with no further teacher training or other support.
- Once set up with adequate gear the anticipated 'hard yards' were not hard.
- Other subjects taught instead of physical science are equally well-justified, important, useful and enjoyable for the pupil.
- The private academic school in the study set a high standard for physical science education and had a specialist science teacher. The students wanted to work at a level beyond that of the workbooks in this study.

From this study it can be concluded that the books made a positive impact for teaching physical science. The books gave teachers an international standard of lessons to work from. They were groundbreaking on several fronts at the time.

The voice from the classroom shouts, *'show me, tell me, tell me again, teach me, give me, let me, help me, guide me, answer me—now!'* *Catch the wave*—there is a frenzy, an urgency, an honesty and immediacy in children's wanting answers and explanations. The biological window opens for a short period and it is critical for responsible adults to be ready with things in place. Books, information, speech, interaction, equipment, space, an infusion of information for every sense and ability from every direction are needed. Education is giving and everything needs to be given from age 9 to 12 to lay the foundations for physical science. When children ask a question they want an answer—not to be frustrated by the lack of books and equipment, not to have the question parroted back at them. Children are honest in their need to know and desire to learn and find things out. From primary school they have a long way to go and need strong foundations, good background knowledge and skills. They want to know - now. They will be hurt if they are frustrated in this simple and natural quest and as a result the nation will suffer.



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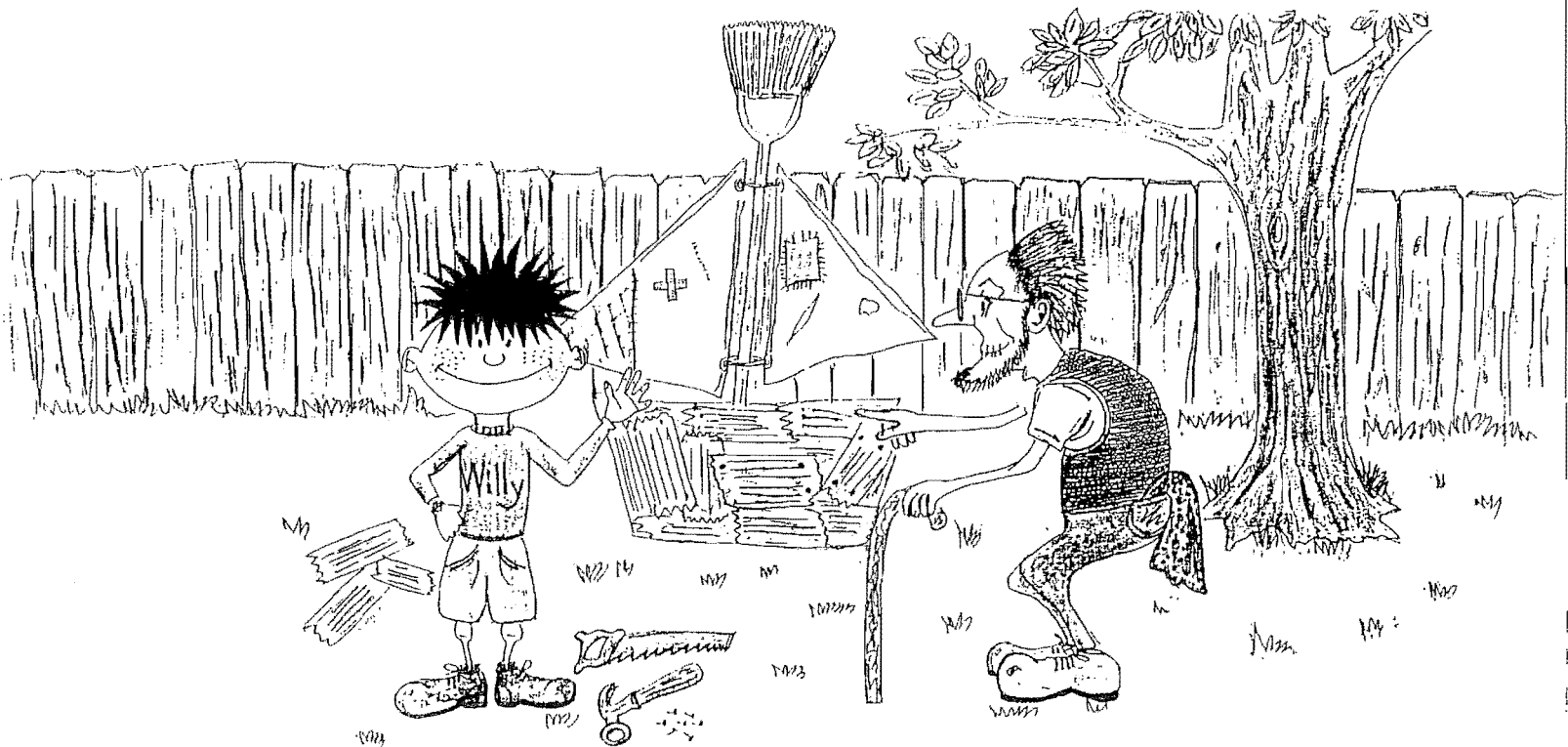
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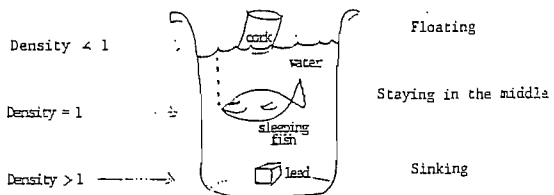


But Willy, will it Float?

Miscellaneous portions from the 'Physics of Floating' workbook used in pilot study.

FLOATING

An object will float if it is less dense than water.
An object will sink if it is more dense than water.



Name:.....

PLEASE DESCRIBE IN YOUR OWN WORDS:

DENSITY

WHY THINGS FLOAT.

Table 1. Comparative Densities

Object	Density	Floats	Sinks	Stays in the Middle
Water	1			
Cork				
Lead				
Fish (sleeping)				
Coin				
Styro-foam				
Kelp				
Rock				
Pumice				

HOW TO MEASURE THE VOLUME OF SOMETHING BY DISPLACEMENT

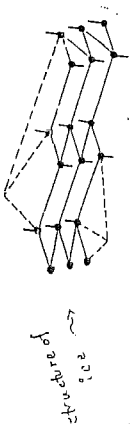
WHAT IS H₂O ?

WHAT IS NaCl ?

The density of water is 1 gram per ml.
If the density of an object is greater than 1 it will sink.
If the density of an object is less than 1 it will float.

HOW CAN YOU GET AN EGG TO FLOAT?

For ice to form, all the water molecules have to be very neatly, something like this.....



...so there is more space between each water molecule. Ice, then, is lighter than water so it floats.

Review

Item	Density (gm/ml)	Floats	Middle	Sinks
Cork	0.25	x		
Wax	0.80	x		
Ice	0.90	x		
Water	1.00		x	
Fish (sleeping)	1.00		x	
Glass	2.50			x
Lead	11.40			x
Gold	19.32			x

If it is less dense than water it floats.
If it is more dense than water it sinks.



**READ ALOUDS SURVEY
FOR YEARS 3 -8 (STD 1 - FORM 2)**

School or Library
(if a teacher or librarian)

Title and Author of Book	Age or Year level of children
Eg. CHARLOTTE'S WEB BY E.B. WHITE recommended for..	YEARS 3-4



Department of Zoology

University of Canterbury

Private Bag 4800
Christchurch New Zealand
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Fax: 03-364 2024

Univ. of Canterbury Research Project:
Physical Sciences for the Pre-Secondary Student

Story/Book Survey For Years 3-8 (Std 1 - Form 2) Chemistry & Physics

A research project at the University of Canterbury is surveying the availability of really good books for children in the 7-12 year age bracket which deal with topics in physics and chemistry, and we'd like your help. Could you list any books you have tried and found successful. Books can include texts, write-on workbooks, picture stories, or any other material relating to physics or chemistry. (Books would not include those relating to biology, geology, botany, zoology, computer science, geography, etc.). Please post the list to:

P.O. Box 2020, CHRISTCHURCH

Your Name _____ Phone _____

School or Library
(Teacher or Librarian) _____

Title/Author of Book	Age or Year Level	Used in Classroom/ at Home/Both

Please use other side of page if needed...

- ?? Would you find it useful if we could provide more material for library, home, and classroom use in the areas of primary physics and chemistry?
- ?? Would it be useful to draw from local, Canterbury life for examples, illustrations, and local language for these books?
- ? Would you endorse this project?

Abstract

Statistical inference is pointless if a system is deterministic. A sample is taken only to measure the degree of compliance. However, in terms of this problem, the system is self regulating, but not entirely deterministic. The presumed cause of under-teaching primary physics (lack of skill) was not totally correct. Another possibility, e.g., lack of resources, was sought. Was there a lack of resources? Could a sample of 17 tell anything about the population of 2,500? The system of schools could be considered cohesive, but not totally homogeneous. A way of conceptualizing an on-the-run sample is presented even though conjectural.

Have a McSample!

L. M. Ko Kozlonskie

Small on-the-run samples have high validity,
albeit low quality, for franchise-type populations.

Since reforms to improve primary education in math, science and technology were introduced to the NZ curriculum in the mid-1990's, Year 1-8 schools have been making progress in adapting to those changes through teacher upskilling, new didactic resources, improved facilities, and so forth. However, gathering hard data on the implementation of these initiatives could require a wait of up to ten years and exceed the normal research budget. And since the system is constantly evolving, in the year it might take to analyze large-scale data, it should already have become obsolete.

For several decades it has been recognized that a wide range of investigative methods are necessary and applicable to different aspects of education research. (Anderson, 1990) For many research problems the use of multiple techniques is not only valid, but useful. For example, the results from a qualitative case study of one principal would correlate highly with results from a quantitative survey of all 2,500 principals.

Niche population

The education setting is unique in many ways. A 1000-page ethnography: '*8 Hours in-the-Life-of-*' one primary principal would not have to be repeated for the next—they'd be nearly identical. Behaviour is codified and deterministic. Variation is unacceptable. By contrast, an in-depth 8-hour case study of one person chosen at random from the general population of 2,500 would be unlike any of the other 2,499. Each would have a unique biography. It would be ludicrous to generalize from one case to all people.

Yet, is it ludicrous to generalize from the single case of one principal? Schools follow common guidelines and norms for the range of activities which occur on the grounds and these are moderated and matched in detail and schools strive to conform. Also, there is a vibrant communication network between schools and within them through daily meetings and so forth. Any change or new information is quickly disseminated.

Franchise population

The 'universe' of the sample is not a theoretical construct: all members of the total population can be indexed. Although there might be 2,500 elementary schools in the country, the same overall procedures, activities, goals and outcomes and same curriculum would be expected and observed for a student walking through the classroom door in Kaitaia as in Gore. Ignoring finer differences and considering only the gross characteristics by which schools are the same, they could be conceptualized as constituting a population of education franchises.

Gourmet vs. budget statistics

At the 'gourmet' end of the range of multivariate statistical methods and applications, subtle differences in abilities and nuances in meaning are described with accuracy and detail, a vital part of education research and high-stakes testing. But at the 'fast food' end of the range, a reliable, simple statistic could depend on the lack of differences between schools, on the gross picture, and on the overall similarity and singular nature of all the schools in the system.

If the systems are similar enough, and time and resources scarce, can confidence be placed on a sample as small as one? Ehrenberg (1975) suggested that results of non-random sampling could be acceptable if the population is more-or-less homogeneous.

Kane (2002) uses the example of electrons as a homogeneous population: any electron chosen will be a representative sample; the population is infinite and the deviation is nil.

"The sampling problem disappears to the extent to which it is possible to assume that the universe is homogeneous."

Because of the homogeneous nature of, say, an international brand of drive-through burger franchise, given 2,500 of them around the world, after one sample it could be stated with nearly 100% confidence,

"The burger in Timaru will taste the same as the burger in Paris"

Kane (2002) further notes, "Even if the population includes units with different values on relevant variables, the population can be considered homogeneous if it is well mixed and each observation is based on a large sample of units."

Homogeneity

When should information from just one, two or three people out of 2,500 be prefaced with adjectives like 'anecdotal' or 'incidental'? Can a 'level of homogeneity' factor be applied to certain populations to allow the information to be stated as fact with a given level of confidence? If there is no need for high quality data which, for example, could be presented as evidence in a court of law, is there a way of justifying sampling which does not conform to the ideal model?

Sample data

Cronbach (1972) points out a common sampling error, "A common practice is to observe a group of persons who are conveniently available to the investigator and then to generalize to a population of persons 'like these'." And Cornfield questions the results when, "Scientists have found it better to apply statistical inference to samples obtained haphazardly than to refuse to use information from those samples or to take the sample data as purely descriptive and relevant only to the sample in hand" (Cornfield & Tukey, 1956).

But, what information is valid even though a critical mass in sample size has not been reached? When might one sample be generalized to all other individuals? Could a confidence level be given to a 'drive-through' sample when it is just one out of millions?

Stacking the odds

An initial action was taken, i.e., a choice made to drive through a particular franchise. The next choice was to take a sample.

Lets make a deal

Viewing sampling as step two in a process might be exemplified by the sometimes perplexing 'Monty Hall' dilemma (Hoffman, 1999). In the TV game show, Lets Make a Deal, a contestant is faced with three doors. Behind two is a booby prize and behind the third a car.

Choose a door

The contestant chooses one door of the three, say door 1, and the host, knowing where the prize is, opens another door behind which is one of the booby prizes. He then gives the contestant the choice of sticking with door 1 or switching to the other door.

Switch or stay?

At that point most contestants feel the odds are 50:50 for switching or staying. And they would be 50:50 for a stranger walking onto the show and having to choose at that point. But for the contestant, the odds are not 50:50, but two thirds in favor of switching (Hoffman, 1999).

It depends

The usefulness of this analogy is only to suggest a view of sampling as step in a sequence. The probability of interest (winning the prize) depends on prior events. In this sense, the first step is choosing the franchise to drive through. Once that door has been chosen, several wrong responses are automatically eliminated. From there on the 'dice are loaded'. Any data which follow have an enhanced inherent probability of being right, i.e., matching the data of other franchises, and could be taken *prima facie* to establish a fact with a level of confidence not possible otherwise.

More confident?

A statement made with even a modest level of confidence could be more useful than the same statement made anecdotally or incidentally. There are instances when using this reasoning to assign a probability to low quality, on-the-run data could be useful and even more ethical than ignoring it altogether or putting it aside until more robust statistics are available.

Non sample

The problem which generated the 'McSample' concept occurred in a project which sought to determine the availability of teaching resources for the newly organized science curriculum.

\$25 (*Yes, twenty five dollars*) Research budget

The total budget for surveying the situation in all New Zealand primary and intermediate schools was NZ \$50 (US \$25). This was enough for a few stamps and envelopes, so a questionnaire was sent out to a representative sample of schools. It was poorly worded, sent

during term break, required the respondent to recall and list books (more off-putting than recognizing known titles), and all the returned responses were from only one province and one economic decile- the top tenth nationwide.

The 17 respondents were in no way statistically representative of all 2,500 primary schools. The only factor in common was that they were primary schools. Statistically it was a non-sample and should have been rejected as being anecdotal, too small, too skewed, and too insignificant to work with.

Dump it!.....or not?

And yet, this handful of replies from teachers, librarians and principals at local schools was inferentially accorded tremendous weight by those who read it. On the basis of those replies a new set of books for four years of curriculum was funded and when the books came out, most schools in the country teaching those grade levels ordered them.

In other words, the original anecdotal sample had been 100% accurate. In hindsight, it was representative of the true population mean. It was low-budget, low quality, on-the-fly data, but turned out to be okay, valid and generalizable. It was non-experimental survey research aimed only at describing one characteristic of the population, not at testing a hypothesis. The question was about resources. With bulk funding, schools get their own, and expenditure is susceptible to a variety of local forces, so this feature is not deterministic. The sample size was too small ($n < 30$) to be considered an approximation of a normal distribution and yet the mean value reflected the true population mean closely if not exactly.

‘Franchise’ population, drive-through sample

From the point of view of this study, although each school consisted of a complex array of ‘units’, all schools existed for the same purpose, with the same set of people and conditions, were striving to deliver the same curriculum, were monitored by the same overarching authority, etc. They were not identical as electrons may be thought to be, but were clumps of units alike enough so that each school could be viewed as a franchise for the national education system, and the budget data as from a McSample.

For this data, no further analysis nor refinement was attempted. It carried a tremendous inherent inferential weight and in the end, was useful to a lot of schools. But statistically it could only be reported as haphazard gossip.

Frustration

Out of frustration at not being able to present it as anything other than hearsay evidence, a way to conceptualize a level of confidence was sought. For that, two assumptions needed to be made and both depended on the fact that the whole universe i.e., every school, was known and could be indexed.

Confidence interval

The first assumption was that a franchise population behaves in a conforming way such that 95% (roughly 2 standard deviations (1.96σ) of the population behaved within a given percent of the mean value. For the sake of argument, for a cohesive population, the hypothetical figure assigned was $\pm 30\%$, i.e. one standard deviation, σ , of 15% . This is an assumed number and since the variable is generic, is reported as a percent (Barton 1997).

Table 1. Definition of Terms and an Equation for the Confidence Interval
<p>Definitions</p> <p>μ = true population mean</p> <p>α = confidence level</p> <p>σ = standard deviation of population</p> <p>\underline{x} = sample mean</p> <p>n = number in sample</p> <p>z = the number of standard deviations in the chosen confidence level</p> <p>Equation for confidence interval</p> $\underline{x} - z \sigma n^{-1/2} < \mu < \underline{x} + z \sigma n^{-1/2}$

The second assumption was that the sample mean (\underline{x}) was approximately normally distributed with the population mean (μ) and standard deviation $\sigma n^{-1/2}$. Values of z , the number of standard deviations in the confidence interval chosen, are found in tables of normal curve areas. These variables and the general formula for confidence interval for the sample mean are in Table 1.

To compensate the assumptions, only a modest confidence level, α of 85% was sought. A confidence interval for the mean, μ , of the total population could then be calculated.

For this sample

Using the sample size $n = 17$ and a sample mean, \underline{x} , of 15% (the mean percent resources) an interval of from 10% to 20% could be hypothesized with a confidence of 85% . That is, assuming that 95% of schools behaved similarly across a spectrum of gross variables to within $\pm 30\%$, it might be possible to assert from the sample of 17 with 85% confidence that in 1998 all schools had only between 10 to 20% of the teaching resources needed for the new 1996 curriculum.

Conclusion

This stochastic paradigm shift may offer justification when a scientist considers retaining a sample which would appear to have been obtained haphazardly as the above quotation, “Scientists have found it better to apply statistical inference to samples obtained haphazardly than to refuse to use information from those samples or to take the sample data as purely descriptive and relevant only to the sample in hand” (Cronfield, 1972). Perhaps the historical and axiological knowledge of the researcher rather than lack of time, insufficient funds, bias or carelessness was involved. Perhaps sampling was not as arbitrary as it appeared because the researcher had not just walked on stage but had come to a position facing a choice with unequal odds.

EVALUATION OF RESOURCES AVAILABLE FOR TEACHING THE PHYSICAL SCIENCES:

THE MATERIAL WORLD AND THE PHYSICAL WORLD

FOR STUDENT AGES 9 - 12

This survey is being conducted to evaluate the quality, appropriateness, and methods of using the physical science text and other resource material commonly available to primary and intermediate schools as compared to what was available in 1997. Ages 9 - 12 are important in educating the general public to a level of confidence about science, and the resources available can be as much a determinant as the teacher and the learning environment. Your input to this survey would be greatly appreciated.

Background Information (please read and tick all responses with which you agree on any question, or give answer as indicated)

In what year did you graduate from a College of Education? _____ What is your gender? male ☐ female ☐

What is your favorite subject area (if any) or subject strength? _____

What year(s) do you teach? Year 4 (Age 8) ☐ Year 5 (Age 9) ☐ Year 6 ☐ Year 7 ☐ Year 8 ☐ Other _____

What is your physics or chemistry background? School Cert Science ☐ 6th Form Chemistry or Physics ☐

6th Form Biology ☐ 7th Form Chemistry or Physics ☐ 7th Form Biology ☐ University Chemistry or Physics ☐

University Biology ☐ Teacher's College Science class ☐ In-service training ☐ Other (please state) _____

With regard to The Material World & Physical World prescriptions, The resources available are sufficient. ☐

In-Service up-skilling courses or other support could be useful. ☐ Case or model lessons would be useful. ☐

The College of Education training suffices to teach these subjects effectively. ☐ Physical science specialists are not needed. ☐

With regard to The Material World and Physical World prescriptions, I prefer teaching biological sciences. ☐

I am personally not interested in those subjects and never liked them. ☐ I download class material from the internet. ☐

My school is just beginning to gear up to teach those subjects. ☐ I have not started teaching those subject areas yet. ☐

I prefer not to teach it at all rather than teach it incorrectly or with disinterest. ☐ There is actually not much to teach about. ☐

I never liked those sciences in school, so find myself avoiding them as a teacher. ☐ I use my own money for resources. ☐

The physical sciences do not have as much intrinsic value for the students at this age level as do other subjects. ☐

Students are not as enthusiastic about these subjects as they are about others. ☐ More "handout" material would be useful. ☐

Since these subjects will be taught at Form 3 and 4, it is not important to spend a lot of time on them in earlier years. ☐

The exact content to be covered in this area is not clear. ☐ Bicarbonate fizzes - so what? There is not much else to teach. ☐

The lessons are boring - observing ice melting and water evaporating is dull. ☐ Pupils are enthusiastic about the activities. ☐

Since the new curriculum has been published, this is a new subject area I am learning more about. ☐

I enjoy this subject area and look forward to teaching it. ☐ The physical sciences require too many math skills. ☐

More concise and de-mystifying background information for teachers would help. ☐ More lab supplies are needed. ☐

My classroom does not have the books / equipment (circle) needed to teach this subject area, so we do other subjects instead. ☐

I have ready access to batteries, bulbs, wires, magnets, retort stands, pulleys, etc. and all the other equipment needed. ☐

My school does not have the budget to purchase equipment needed to teach this. ☐ My science cupboards are well stocked. ☐

School Demographics

How many students are at your school? _____ In what decile is your school? _____ What region? _____

Is your school... Yr 0 - 6 ☐ Yr 0 - 8 ☐ Yr 0 - 13 ☐ Yr 7 - 8 ☐ Yr 7 - 13 ☐ Other _____

Te Kura Kaupapa Maori ☐ Composite Area School ☐ Sole Charge ☐ Small Town ☐

Rural ☐ City ☐ Private ☐ Religious Affiliate ☐ Other _____

Do you have a combined (i.e., two years together) class? _____ What year(s) is your class? _____

What is the age range of your class? _____ The median age? _____ How many students are in your class? _____

Your teaching language(s) ? _____ Your students' spoken language(s) ? _____

Teaching Practice

In our school, subjects are taught in combination, so the exact number of hours spent on physical science is not specified. ☐

In terms of formal teaching hours the physical sciences are allocated approximately _____

(or, _____ hrs per week, _____ hrs per term, _____ hrs per year, _____ hrs per two-year cycle, or etc.)

We teach over a... one year ☐ two year ☐ three year ☐ four year ☐ cycle. (or other _____)

We...do / do not... frequently structure lessons around a handout. There...are / are not... enough resources in these subjects.

The way we/I make use of the resources is: _____

(attach extra paper)

Resources for The Material World and The Physical World

Resources you have. ('Resources' include books, videos, people, internet, Maori language, helplines, games, etc.)

Please list resource material which has been useful to you in teaching the Material and/or Physical World, if any.

Please note the source (internet, MOE, publisher, etc.) if possible; list supplementary or library material as well.

Resources you want. Please list what would suit your needs best, and what you would ideally like to have.

Thank you very much for your help.

Voluntary confidential info for further notices, etc.: Your Name: _____ Address: _____ _____ _____ _____

Tick here if you wish to be in the draw to win some books. ☐

STUDENT BOOK SURVEY FOR THE PHYSICAL SCIENCE WORKBOOK

First Name: _____ Age: _____ Grade: _____ Book Number: 1, 2, 3 or 4. _____

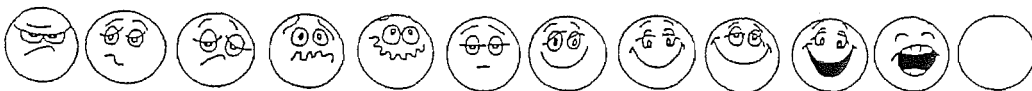
1. Was the book clear? (please circle one) yes / usually / sometimes / no
2. Did you write in the book? yes / usually / sometimes / no
3. Were the illustrations clear? yes / usually / sometimes / no
4. Did you like colouring in the book? yes / usually / sometimes / no
5. Did you like working in groups? yes / usually / sometimes / no
6. Did you complete the activities which you started? yes / usually / sometimes / no
7. Did you have enough equipment? yes / usually / sometimes / no
8. Did you like having your own book? yes / usually / sometimes / no
9. Did you ever take it home? yes / usually / sometimes / no
10. How much of the book did you do? a little / some / a lot / all of it
11. Which topic(s) did you like most? _____
12. Was there a topic you did not like? _____
13. What would you like to learn (more) about? _____
14. Some good things about this book are: _____

15. Is there anything about the book you would change to make it better? _____

16. What I like about doing science is: _____

17. Is there anything about it you do not like? _____

18. Before I read this book, my attitude toward physical science was...(tick one or draw your own)



19. After using this book, my attitude toward toward physical science is...(tick one or draw your own)



20. Please write Yes (True) or No (False) for your own opinion:

- When I first got the book I looked through the whole book. _____
- I can read the book. _____
- I know what this subject is about because I looked through the book. _____
- The pictures in the book help me understand what it is about. _____
- I can look at the pictures to understand the activities. _____
- I can read the book and discuss it or ask questions about it. _____
- I can look in the book if I want to know what we will be doing. _____
- Sometimes if the room is too noisy or I am doing something, I cannot hear what the teacher says. _____
- Sometimes I cannot read the board at the front of the room. _____
- Sometimes my handout sheets get torn, ripped, crumpled up in my desk, tossed in the bin or lost. _____
- The information in books is usually more important than the information on handout sheets. _____
- When I write in the book I can see what I have accomplished. _____
- I can look back in the book to remember the things I did. _____
- Since I have the book I can get on with the work when I'm ready. _____

21. What do you remember now about using the book? (please take your time)

I remember.....

...what I said in class.	not much / some / a lot of it
...the activities we did.	not much / some / a lot
...what was on the board.	not much / some / a lot
...what other students said.	not much / some / a lot
...what I wrote down.	not much / some / a lot
...the pictures in my book.	not much / some / a lot
...the reading in my book.	not much / some / a lot
...what the teacher said.	not much / some / a lot

22. Your comments: _____

Thank you for completing this book survey.

TEACHER BOOK SURVEY FOR THE
PHYSICAL SCIENCE STUDENT WORKBOOK

Name: _____ School: _____ Date _____

Number of Students in Class: _____ Ages : _____ Grade(s): _____ Book Number: 1, 2, 3 or 4 .

- My overall rating of this book is...(circle one)... 1 2 3 4 5 (high)
- The things I liked about the book: _____

3. The things I would change or improve: _____

4. For a Science Workbook, did it provide opportunities for building the following skills?

1	Literacy Skills	1	2	3	4	5	(yes)
2	Reading Skills	1	2	3	4	5	
3	Writing Skills	1	2	3	4	5	
4	Oral Skills	1	2	3	4	5	
5	Numerical Skills	1	2	3	4	5	
6	Observational Skills	1	2	3	4	5	
7	Problem Solving Skills	1	2	3	4	5	
8	Aural/Listening Skills	1	2	3	4	5	
9	Questioning Skills	1	2	3	4	5	
10	Organizational Skills	1	2	3	4	5	
11	Planning Skills	1	2	3	4	5	
12	Technical Skills	1	2	3	4	5	
13	Hands on Physical Skills	1	2	3	4	5	
14	Cooperative Learning Skills	1	2	3	4	5	
15	Creative Skills	1	2	3	4	5	

Other skills (please list any others)

16 _____	1	2	3	4	5
17 _____	1	2	3	4	5
18 _____	1	2	3	4	5

5. Please comment on the following:

Book size: _____

Book length: _____

Write-on format: _____

Colour-in format: _____

Black and white format: _____

Paper thickness: _____

Laminated cover: _____

Low text/high illustration format: _____

Hand-drawn, 3-D illustrations (as opposed to 2-D, computer drawn ones):

Readability: _____

Font size: _____

Other: _____

6. Yes / No

a. Each student had his/her own book. _____ Comments:

b. The students found the workbook largely self-explanatory. _____
Comments

c. It helps in the learning process for each student to have his/her own book. _____ Comments

d. The language level and vocabulary in the books is appropriate. _____
Comments

e. There is sufficient information in the Teacher Guide to answer any questions which might arise. _____ Comments

f. The Teacher Guide is adequate so that a person without a science background may teach the material. _____ Comments

g. It is convenient to have a book which covers the syllabus in these subject areas. _____ Comments

h. I would use Teaching Videos to accompany this book. _____

Comments

i. I can supplement the book with material from other sources. _____

Comments

j. I would use this book as a core text again next year. _____

Comments

k. I had all the equipment needed to do all the activities. _____

Comments

l. I would order a set of these books for my class. _____

Comments

m. It would be best if pupils used Books 1 - 4 sequentially from Yr 5 - Yr 8. _____
Comments

n. Overall, for the level to which my class is accustomed, this book was...
(assuming Bk 1 for age 9, Bk 2 for 10, Bk 3 for 11, Bk 4 for 12)(circle one)
a little easier just right a little harder
Comments

7. How does using a class set of write-on student workbooks compare with using sets of Photocopy Masters with respect to...

...organization over the year	1	2	3	4	5	(better)
...continuity in learning over the year	1	2	3	4	5	
...focus in learning over the year	1	2	3	4	5	
...coherence of information	1	2	3	4	5	
...convenience for student	1	2	3	4	5	
...convenience for teacher	1	2	3	4	5	
...time saving for teacher	1	2	3	4	5	
...classroom management	1	2	3	4	5	
...time saving for the students	1	2	3	4	5	
...cost savings over the year	1	2	3	4	5	

other: _____

Thank you for your interest in the Primary Science Project.

The aim of this project is to understand how pre-secondary science is taught and in what ways the resources produced to serve the teaching professional can be enhanced and improved. In order to do this we need the advice and insights of trained classroom teachers.

Keeping notes in a journal over the course of a school year is one way this information can be acquired. Such a journal can be organized in whatever way suits the requirements of the teacher. A sample outline is shown below, but this is not to imply any limit to the range of topics which might be noted, or how those notes are organized.

Topic:

Date(s):

Book & Page:

Teacher(s):

Class:

Number of Pupils:

Teaching Method(s):

Age Range:

- *Preparation/Set-up/Equipment:*
- *Results/What we did/How we did it:*
- *Analysis/Problems/What worked, what didn't:*
- *Evaluation/Conclusion:*
- *Advice/Suggestions/Comments:*

INFORMATION

You have been invited to participate in the research project titled
Physical Science for the Primary Student

The aim of this project is to understand what and how pre-secondary physical science is taught, what the barriers to teaching in this subject area might be, and in what ways the materials produced to serve the teaching professional can be improved and enhanced. In order to do this we need the advice and insights of trained classroom teachers *in situ*.

Your participation in this project will involve, (i) receiving a class set (or sets) of books titled 'Pre-Secondary Physical Science Workbook' 1, 2, 3 or 4 - one for each pupil - and an accompanying Teacher Guide, (ii) making use of the books in your classroom over the year 2001, and (iii) keeping notes in a journal each time the books are used and when physical science is taught using other resources. The books are to be used entirely at your discretion and according to your judgment as to what is best for your classroom.

The results of this project may be published, but you can be assured of the absolute and complete confidentiality of data gathered in this investigation: the identity of participants will not be made without their written consent. To ensure anonymity and confidentiality all original information is maintained in a locked file in a locked office at the University and is accessible only to the project coordinator and no copies of original information are made. At the conclusion of the collation of data, your journal will be returned to you.

Consent Form - Teacher

(Please return one copy.)

Physical Science for the Primary Student

I have read and understood the description of the project above. On this basis I agree to participate as a professional in my-area of teaching. I consent to the publication of the results of the project with the understanding that anonymity will be preserved.

I understand also that I may at any time withdraw from the project, including withdrawal of any information I have provided.

Name:

Signature: Date:

INFORMATION

You have been invited to participate in the research project titled
Physical Science for the Primary Student

The aim of this project is to understand what and how pre-secondary physical science is taught, what the barriers to teaching in this subject area might be, and in what ways the materials produced to serve the teaching professional can be improved and enhanced. In order to do this we need the advice and insights of trained classroom teachers *in situ*.

Your participation in this project will involve allowing the work you have done in the 'Pre-Secondary Physical Science Workbook' Vol. 1, 2, 3 or 4 to be sent to the science education research student.

Parts of this material may then be published in a final report, but you can be assured of the absolute and complete confidentiality of the identity of all participants which will not be made public without their written consent. To ensure anonymity and confidentiality all original material is maintained in a locked file in a locked office at the University and is accessible only to At the conclusion of the study, the books will be returned to the participants.

Consent Form - Pupil
Physical Science for the Primary Student

(Please return one copy.)

I have read (or have had read to me) and understood the description of the project above. On this basis I agree to participate. I consent to the publication of my submitted work with the understanding that my anonymity will be preserved. I understand also that I may at any time withdraw my material from the project.

Name: Age:
Signature:
Date:

INFORMATION

You have been invited to participate in the research project titled
Physical Science for the Primary Student

The aim of this project is to understand what and how pre-secondary physical science is taught, what the barriers to teaching in this subject area might be, and in what ways the materials produced to serve the teaching professional can be improved and enhanced. In order to do this we need the advice and insights of trained classroom teachers *in situ*.

Your participation in this project will involve allowing the work _____(the pupil) has done in the ‘Pre-Secondary Physical Science Workbook’ Vol. 1, 2, 3 or 4 to be sent to the science education research student

Parts of this material may then be published in a final report, but you can be assured of the absolute and complete confidentiality of the identity of all participants which will not be made public without their written consent. To ensure anonymity and confidentiality all original material is maintained in a locked file in a locked office at the University and is accessible only to _____. At the conclusion of the study, the books will be returned to the participants.

Consent Form - Responsible Adult
Physical Science for the Primary Student

(Please return one copy.)

I have read and understood the description of the project above. On this basis I agree to the participation of _____, Age _____, and consent to the publication of any submitted material with the understanding that anonymity will be preserved. I understand that I may withdraw this material from the project at any time.

Name:.....
Signature:
Date:.....

HOW DID YOU LIKE THE SCIENCE WORKBOOKS?

STUDENT OPINION SURVEY

First Name: _____ Age: _____ School: _____

1. The Workbook(s) I used: ☐ Book 1 ☐ Book 2 ☐ Book 3 ☐ Book 4
2. My rating of the book is: (circle) 1 2 3 4 5 6 7 8 9 10 (great!)
3. My comments about it: e.g., "What I liked best was..."

4. Thank you very much!



UNIVERSITY OF CANTERBURY - HUMAN ETHICS COMMITTEE

APPLICATION FOR ETHICAL REVIEW AND APPROVAL

This form should be completed in the light of the Principles and Guidelines issued by the Human Ethics Committee. Applicants must read those before filling out the application form. The latest versions of both the Guidelines and the Application Form can be found on the website of the Research Office.

website: <http://www.research.canterbury.ac.nz>

email: enquiries@research.canterbury.ac.nz

PLEASE SEND eight printed or typed copies of the completed form, duly signed by applicant and supervisor or Head of Department, and of the relevant documents referred to in questions 3, 7, 8, 9, 10, 12, 16, to the Human Ethics Committee, c/o Isobel Phillips, Old Maths Building.

1. PROJECT NAME: Physical Science for the Primary Student

2. NAME OF APPLICANT: Laura M Kozlonskie

Contact Telephone No: 03-381-0384

UNIVERSITY DEPARTMENT (or other contact address): Zoology

email address (if available):

STATUS OF PROJECT (e.g., EDUC XYZ class project, M.A., M.Ed., M.Sc., Ph.D., Staff research study)

SUPERVISOR: Dr. Kelvin Duncan

OTHER INVESTIGATORS:

SIGNED BY: Applicant: Laura M Kozlonskie Date: 22-5-01

HOD/Supervisor: [Signature] Date:

3 (a) WILL THE PROJECT REQUIRE ETHICAL APPROVAL FROM OTHER BODIES? e.g. Regional Health Authority Ethics Committee
If Yes please explain how this approval has been or will be obtained, enclosing copies of relevant correspondence.

Delete which ever is in-applicable
Yes/No

(b) WILL THE PROJECT REQUIRE APPROVAL FOR ACCESS TO THE PARTICIPANTS FROM OTHER INDIVIDUALS OR BODIES? (e.g., parents, guardians, school principals, teachers, boards, responsible authorities, etc.)
If Yes please explain how this approval has been or will be obtained, enclosing copies of relevant correspondence

Yes/No

4 (a) IS THE PROJECT BEING EXTERNALLY FUNDED?
If Yes, please identify the source of funds.

Yes/No

(b) IS THE PROJECT COMMISSIONED BY, OR CARRIED OUT ON BEHALF OF AN EXTERNAL BODY?
If Yes, please identify the body.

Yes/No

Answer the following questions in language which is, as far as possible, comprehensible to lay people.

- 5 AIM To implement and facilitate the teaching and learning of the physics and chemistry curriculum in late primary and intermediate school years.
- (a) What is the objective of the project?
- (b) Describe the type of information sought. Details at every level of the cognitive and non-cognitive factors involved
- (c) Give the specific hypothesis, if any, to be tested.

The four-years of materials we have produced make a positive impact

- 6 PROCEDURE Describe in practical terms how the participants will be treated, what tasks they will be asked to perform, etc. Indicate how much time is likely to be involved in carrying out the various tasks. Participants are asked to maintain an action-research-type journal as they implement the physical sciences

- 7 DOES THE PROJECT INVOLVE A QUESTIONNAIRE? Yes/No

If Yes, please attach a copy, if possible.

[Note:- The HEC does not normally approve a project which involves a questionnaire without seeing the questionnaire, although it may preview applications in some cases where the production of the questionnaire is delayed for good reason.]

- 8 (a) DOES THE PROJECT INVOLVE A STRUCTURED INTERVIEW? Yes/No
If Yes, please list the topics to be covered and the questions to be used.

- (b) DOES THE PROJECT INVOLVE AN UNSTRUCTURED INTERVIEW? Yes/No
If Yes, please list the range of topics likely to be discussed.

- (c) IF THE PROJECT INVOLVES AN INTERVIEW OF EITHER TYPE, WILL IT BE RECORDED BY: AUDIO-TAPE Yes/No
OR VIDEO-TAPE? Yes/No

- (d) WILL THE PARTICIPANTS BE OFFERED THE OPPORTUNITY TO CHECK THE TRANSCRIPT OF THE INTERVIEW? Yes/No

B. PARTICIPANTS

- 9 (a) WHO ARE THE PARTICIPANTS? Registered, practicing primary teachers

- (b) HOW ARE THEY TO BE RECRUITED? Notice in Education Gazette-attached
If recruitment is by advertisement or letter or notice, please attach a copy.

- (c) WILL ANY FORM OF INDUCEMENT BE OFFERED? Yes/No
If Yes, please give details and a brief justification.

- (d) IF A SELECTION FROM A GROUP IS NECESSARY, HOW WILL IT BE MADE? First come, first served.
(e.g., randomly, by age, gender, ethnic origin, other - please give details.)

- (e) HOW MANY PARTICIPANTS (OF EACH CATEGORY, WHERE RELEVANT) DO YOU INTEND RECRUITING? A minimum of three at each of four levels

10. WHAT INFORMATION IS BEING GIVEN TO PROSPECTIVE PARTICIPANTS?
Please attach a copy of the Information Sheet (or sheets if there are different categories of participant or if responsible persons, other than participants, need to be informed).

attached

[NOTE:- Projects which involve only an anonymous questionnaire may not necessarily require a separate information sheet, provided that the rubric of the questionnaire includes your name and contact number as well as the other points contained in the model shown in the GUIDELINES. In general, however, the HEC recommends that participants be given an information sheet, which they may retain, unless there are good reasons against such a procedure.]

11. ARE THE PARTICIPANTS COMPETENT TO GIVE INFORMED CONSENT ON THEIR OWN BEHALF? Yes/No
Teachers-yes, Pupils-no The pupils are 9-12 yrs
If No, please explain: so dependent persons.
(a) why they are not competent to give informed consent on their own behalf.
(b) how consent will be obtained. Forms posted

12. WILL CONSENT BE OBTAINED IN WRITING? Yes/~~No~~
If Yes, please attach a copy of the Consent Form which will be used.

[Note:- Separate consent forms may be required if there are different categories of participant, or if consent is needed from responsible persons, other than participants.]

If No, give reasons for this.

13. HOW WILL THE ANONYMITY OF THE PARTICIPANTS BE ASSURED?
(a) If any identifying information about the participants is obtained at any stage of the project, how and where will such information be securely stored?
Everything kept in a locked file in Rm 206, Old Maths Bldg.
(b) Who will have authorised access to such information?
Only the Research applicant.
(c) What will be done to ensure that the identities of the participants cannot be known by unauthorised persons? All information concerning identity is kept at all times in the locked file in the locked room.

C. OTHER PROJECT DETAILS

14. WHERE WILL THE PROJECT BE CONDUCTED? In the school classroom.
15. FORESEEABLE RISKS TO THE PARTICIPANTS None

- (a) Is there any risk to physical well-being? Yes/No
(b) Could participation involve mental stress or emotional distress? Yes/No
(c) Is there a possibility of giving moral or cultural offence? Yes/No

If the answer to any of those questions is "Yes", please indicate briefly the nature of the risk and what actions you could take, or support mechanisms you could rely on, if a participant should become injured, distressed or offended while taking part in this project.

16. IS DECEPTION INVOLVED AT ANY STAGE OF THE PROJECT? Yes/No

[NOTE: The use in the information sheet or consent form or questionnaire of a title which differs from the project title given in this application form, in order not to reveal the real aim of the project, is considered to be a form of deception - however mild.]

If Yes, please

- (a) explain how and why it is to be used and how the participants will be 'debriefed' following their participation in the project.
(b) attach a copy of the debriefing sheet prepared for use by the researcher or for distribution to the participants after their participation in the project or after the completion of the project.
17. WILL INFORMATION ABOUT THE SUBJECTS BE OBTAINED FROM THIRD PARTIES? Yes/No
If Yes, please state:
(a) the identity of the third party or parties.
(b) why such information is needed.
(c) whether appropriate consents for access to such information have been or will be obtained.
(d) whether the use of such data in your research project needs the consent of the participants.

[NOTE: It may happen that by virtue of your job, you have right of access to information concerning the participants. Such information may have been given by the participants for a particular purpose or collated by yourself or colleagues in the normal course of your job. The use of such information for a quite different purpose (i.e., a research project culminating in some form of report) may well require that potential participants at least be informed that their agreement to participate may involve such use. The Information Privacy Principles should be consulted for guidance in this area.]

D. DATA

18. HOW WILL CONFIDENTIALITY OF THE DATA BE ASSURED?

- (a) Where will the data be securely stored? In a locked cabinet in 206 Old Maths B
- (b) Who will have authorised access to the data? Only the research applicant.
- (c) What will be done to ensure that unauthorised persons do not have access to the data? No unauthorized person has access to the room.
- (d) What will happen to the raw data at the end of the project? Returned to participants.

19. ARE THERE PLANS FOR FUTURE USE OF THE DATA BEYOND THOSE ALREADY DESCRIBED?

Yes/No

If Yes, please describe the future use.

[NOTE: It may be the case that such future use should properly involve the production at an appropriate later date of additional information sheets and/or consent forms prior to such use. In that case, copies of those additional documents should be sent to the Human Ethics Committee, along with a covering letter referring to the present project, for HEC approval.]

E CHECK LIST

Please check the following items before sending the completed form to the Committee.
Circle N.A. i.e., Not Applicable, where appropriate.

- | | |
|---|---|
| All the necessary signatures on page 1 have been obtained. | <input checked="" type="checkbox"/> |
| All the necessary approvals under Q 3 have been obtained or are the subject of correspondence of which copies are attached. | <input checked="" type="checkbox"/> or N.A. |
| A copy of any questionnaire, with an appropriate rubric at the beginning or accompanied by an appropriate covering page, is attached. | <input checked="" type="checkbox"/> or N.A. |
| A list of interview topics and, for a structured interview, a reasonably detailed list of questions, is attached. | <input checked="" type="checkbox"/> or N.A. |
| A copy of any advertisement, or notice, or informative letter asking for volunteers is attached. | <input checked="" type="checkbox"/> or N.A. |
| A copy of each information sheet required is attached. | <input checked="" type="checkbox"/> or N.A. |
| A copy of each consent form required is attached. | <input checked="" type="checkbox"/> or N.A. |
| A copy of the required debriefing sheet is attached. | <input checked="" type="checkbox"/> or N.A. |

Attention to the preceding check list is intended to ensure that the application and its documentation have been thoroughly reviewed by the applicant and (where applicable) by the supervisor and that the preparation of the project is up to the standard expected of and by the University of Canterbury.

The signature of the applicant will be understood to imply that the applicant has designed the project and prepared the application with due regard to the principles and guidelines of the HEC, that all the questions in the application form have been duly answered and that the necessary documentation has been properly formulated and checked.

APPLICANT'S NAME and SIGNATURE:- Laura M Laura M. Kordondia

The signature of the supervisor will be understood to imply in addition that, in the judgement of the supervisor, the design and documentation are of a standard appropriate for a research project carried out in the name of the University of Canterbury or for training in such research.

SUPERVISOR'S NAME:-and SIGNATURE:-

KW Duncan KW Duncan

4 July 2001

COPY FOR YOUR
INFORMATION

Laura M

Department of Zoology
UNIVERSITY OF CANTERBURY

Dear Laura

The Human Ethics Committee advises that your research proposal "**Physical Science for the Primary Student**" has been considered and approved.

Yours sincerely

Isobel S Phillips
Secretary